North Water Polynya Conference

Copenhagen 22-24 November 2017

Program with abstracts

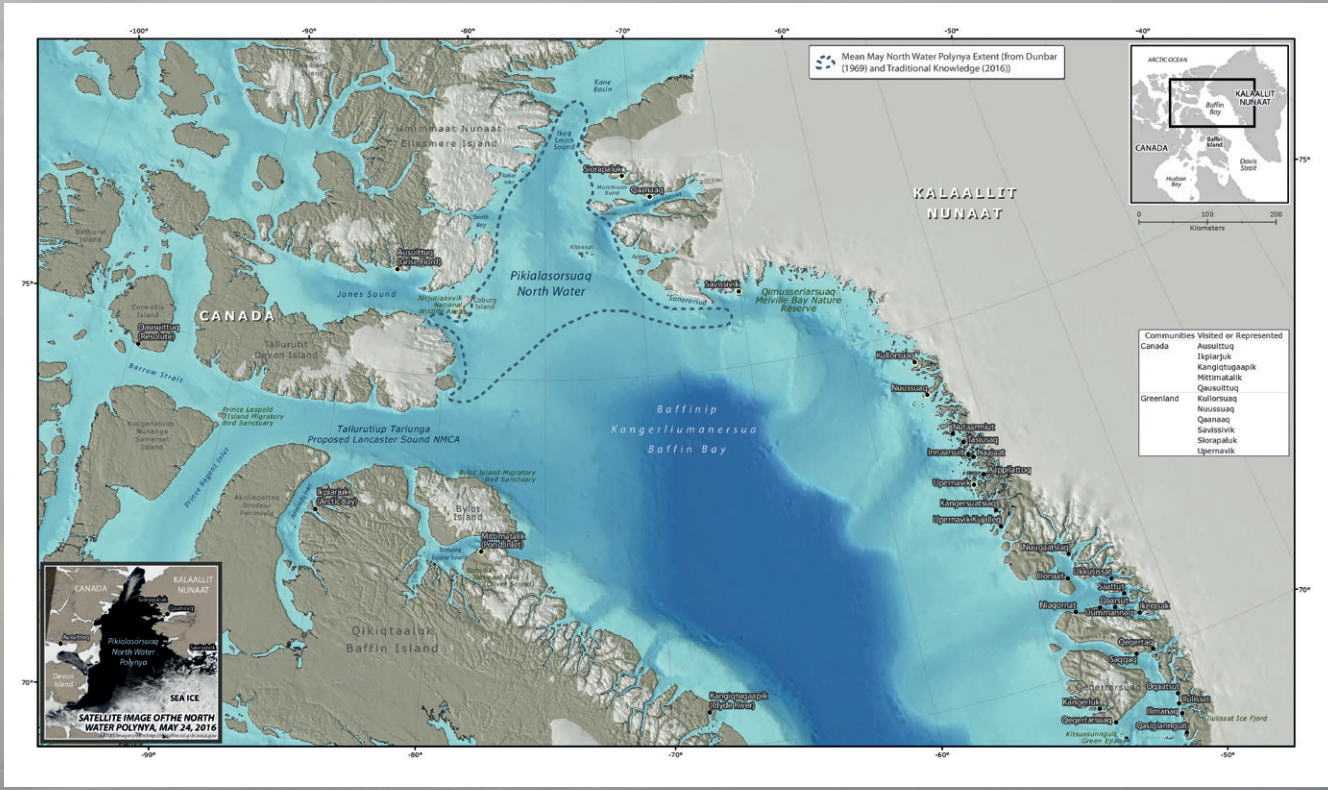
AARHUS UNIVERSITY

Grønlands Naturinstitut
Pinngortitaleriffik · Greenland Institute of Natural Resources

The North Water Polynya Conference is arranged by Aarhus University and Greenland Institute of Natural Resources.

The North Water Polynya Conference is funded by Oceans North, Canada.

The North Water Polynya Conference has also received financial support from the Danish Environmental Protection Agency as part of its Arctic Environmental Support Program, and from the NOW project funded by the Velux Foundations and Carlsberg Foundation.



Note

- *Oalugiarneq torrutiinnarlugu kalaallisuunngortinneqassaaq*
- *In the program means that the talk will be simultaneously translated to Greenlandic.*
- *Disse foredrag simultantolkes til grønlandsk*

CONFERENCE PROGRAM

Tuesday 21st November

17:00-20:00 **Registration** in the Lobby at hotel Scandic Sydhavnen
18:00-21:00 **Icebreaker** with buffet Hotel Scandic Sydhavnen
21:00-?? Copenhagen downtown?

Wednesday 22nd November

08:30-09:45 Coffee and registration (60 min)
09:45-09:50 Official opening of the NOW conference by **Anders Mosbech**
09:50-09:55 Welcome by the Canadian ambassador **Emi Furuya**
09:55-10:10 **Anders Mosbech** Introduction to the NOW Polynya Conference

Physical oceanography and Holocene changes

Session chair: Eva Friis Møller

10:15-10:45 **Key note speaker: Søren Rysgaard** – Climate change, carbon cycling and air-sea exchange

10:45-11:15 **Key note speaker: C.J. Mundy** – The North Water Polynya sea ice environment – a review of physical processes and biological implications

11:15-11:30 **Dany Dumont** – The North Water ice bridge shape and life cycle variability and its impact on the physical oceanography

11:30-11:45 **Till Soya Rasmussen** – The representation of the North Water in coupled ocean and sea ice models

11:45-12:00 **Steffen M. Olsen** – Winter stratification of the High Arctic Inglefield Fjord 2011-2017

Lunch (60 min)

Session chair: David Boertmann

13:00-13:30 **Key note speaker: Sofia Ribeiro** – Sea ice conditions and primary productivity in the North Water Polynya – the past 4000 years

13:30-13:45 **Audrey Limoges** – Late Holocene changes in primary production and sea-surface conditions in the North Water Polynya

13:45-14:00 **Thomas A. Davidson** – Greening the high Arctic : When and how have seabirds transformed the fresh waters of the NOW Polynya?

14:00-14:15 **Martin Appelt** – Historical and archaeological records as proxies for the dynamics of the North Water ecosystem

14:15-14:30 **Discussion**

Coffee (30 min)

Wednesday 22nd November

Marine productivity and food web studies

Session chair: Mark Mallory

15:00-15:30	**Key note speaker: Louis Fortier** – The winter ecosystem: A gap in our understanding of the North Water
15:30-15:45	**Igor Eulaers** – The use of ecogeochemical tracers to quantify food web dynamics in the Northwater region
15:45-16:00	**Douglas Causey** – Evidence for increasingly rapid destabilization of coastal Arctic foodwebs
16:00-16:15	**Jean-Éric Tremblay** – Is the North Water still a biologically productive oasis?
16:15-16:30	**Eva Friis Møller** – Why is the North Water Polynya Region such an important breeding area for little auks?
16:30-16:45	**Mathieu LeBlanc** – Importance in the timing of the North Water (NOW) Polynya formation for polar cod *Boreogadus saida* and its zooplankton prey
16:45-17:00	**Jakob Thyrring** – Identifying climatic drivers of range expansion of a boreal species into the North Water
17:00-17:15	**Discussion**

Poster, Movies, Talks and Tapas

17:15-18:15	**Posters, drinks and snacks (In the Lobby)**
	Natascha Kumar – Climate and environmental change over the past 4000 years in a High Arctic polynya – a biomarker approach
	Karl Brix Zinglersen – Update and detailing of the IBCAO bathymetry model over Greenland
18:15-18:25	**Astrid Andersen** – Introduction to the Piniariarneq project (In the auditorium) *
18:25-18:40	**Piniariarneq – movie**
18:40-19:30	Questions and discussion with participation of the hunters **Olennguaq Kristensen and Mads Ole Kristiansen** *
19:30-22:00	**Tapas and more drinks (In the Lobby)**

Thursday 23rd November

Populations of Marine mammals, birds and fish

Session chair: Flemming Merkel

08:30-09:00 **Key note speaker: Mads Peter Heide-Jørgensen** – Overview of the populations and assessing sustainability of current use of living ressources and new potentials *

09:00-09:15 **Rikke Guldborg Hansen** – A comparison of the abundance and distribution of marine mammals wintering in the North Water Polynya and the North East Water Polynya – Is it NOW or NEW? *

09:15-09:30 **Eva Garde** – The Walrus in Smith Sound *

09:30-09:45 **Anders Mosbech** – Little auk and thick-billed murre in the NOW Polynya *

Coffee (30 min)

10:15-10:30 **Kurt K. Burnham** – Status of peregrine falcon and gyrfalcon populations in northwest Greenland *

10:30-10:45 **Jesper Boje** – Fisheries in the northern Baffin Bay and its future potential *

10:45-11:00 **Kasper Lambert Johansen** – The Piniariarneq Project: Inughuit hunters map their important hunting areas *

11:00-11:15 **Olennguaq Kristensen and Mads Ole Kristiansen** – The Piniariarneq project: Comments from the hunters *

11:15-11:30 **Parnuna Egede** – Interactive atlas of Inuit knowledge on the Pikialasorsuaq ecosystem, and past and present use of living resources *

Lunch (60 min)

Human stressors

Session chair: Parnuna Egede

12:30-13:00 **Key note speaker: David Boertmann** – Anthropogenic stressors in the NOW – today and in the future *

13:00-13:15 **Mette Frost** – Modelling oil spill trajectories in Melville Bay and the North Water Polynya *

13:15-13:30 **Line A. Kyhn** – Seismic surveys in Baffin Bay and the Greenland regulation *

13:30-13:45 **Key note speaker: Rune Dietz** – How the traditional lifestyle and diet in the Northwater region are challenged by long-range pollution *

Thursday 23rd November

13:45-14:00 **Jennifer Burnham** – Status of mercury concentration in twenty-four bird species in northwest Greenland *

14:00-14:15 **Erin Keenan** – Tools for Marine Conservation Planning in the Eastern Canadian Arctic *

14:15-14:30 **Discussion**

Coffee (30 min)

Round table discussion on the future of the NOW

- identification of the most urgent research questions for informing and planning for the future.

Session chair and facilitator: Anders Mosbech

15:00-15:10 **Anders Mosbech**: The future of the NOW, research questions – introduction to the round table discussion *

15:10-15:20 **Kuupik Kleist** (Pikialasorsuaq Commission) *

15:20-15:25 **Karen Motzfeldt** (Ministry of Nature and Environment, Naalakkersuisut / Government of Greenland) *

15:25-15:30 **Lisbeth Ølgaard** (Ministry of Environment and Food, Denmark) *

15:30-15:35 **Vicki Sahanatien** (Nunavut Wildlife Management Board) *

15:35-15:40 **David Lee** (Nunavut Tunngavik Inc.) *

15:40-15:45 **Joel Ingram** (Oceans Program Central and Arctic Region, Fisheries and Oceans Canada)

15:45-15:50 **Olennguaq Kristensen** (President in Savissivik, Association of Fishers and Hunters in Greenland, KNAPK) *

15:50-15:55 **Mads Ole Kristiansen** (President in Qaanaaq, Association of Fishers and Hunters in Greenland KNAPK) *

16:00-17:00 Round table discussion with scientists and stakeholders *

17:00-17:10 **Anders Mosbech**, Round-up and closure

Banquet (19:00- 01:00)

Friday 24rd November

Workshop on Research coordination and planning

Come, join and share your plans and ideas for future Projects in the NOW. Focus will be on research needs, and the potential for scientific and logistic synergy in the region at large.

Introduction from **Søren Rysgaard**, **Mark Mallory** and others.

Sign up by sending an email to NorthWaterPolynia@bios.au.dk

Location: "**Aluminium**" – ground floor

08:30-09:00	**Coffee**
09:00-11:30	**Workshop**
11:30-12:30	**Lunch**

FULL LIST OF AUTHORS

Physical oceanography and Holocene changes

Søren Rysgaard
– Climate change, carbon cycling and air-sea exchange

D.G. Barber & **C.J. Mundy**
– The North Water Polynya sea ice environment – a review of physical processes and biological implications

Dany Dumont
– The North Water ice bridge shape and life cycle variability and its impact on the physical oceanography

Till Soya Rasmussen, Mads Hvid Ribergaard, Nicolai Kliem & Eigil Kaas
– The representation of the North Water in coupled ocean and sea ice models

Steffen M. Olsen
– Winter stratification of the High Arctic Inglefield Fjord 2011-2017

Sofia Ribeiro
– Sea ice conditions and primary productivity in the North Water Polynya – the past 4000 years

Audrey Limoges, Sofia Ribeiro, Kaarina Weckström & Guillaume Massé
– Late Holocene changes in primary production and sea-surface conditions in the North Water Polynya

Thomas A. Davidson, Ivan Gonzalez-Bergonzoni, Kasper Johansen, Sebastian Wetterich, Hanno Meyer, Torben Windirsch, Erik Jeppesen, Jesper Olsen, Frank Landkildehus, Astrid Strunk, Rune Dietz, Igor Eulaers, Nicolaj Larsen & Anders Mosbech
– Greening the high Arctic : When and how have seabirds transformed the fresh waters of the NOW Polynya?

Martin Appelt, Bjarne Grønnow & Kirsten Hastrup
– Historical and archaeological records as proxies for the dynamics of the North Water ecosystem

Marine productivity and food web studies

Louis Fortier
– The winter ecosystem: A gap in our understanding of the North Water

Igor Eulaers, Rune Dietz, Gilles Lepoint, Jochen Zubrod & Anders Mosbech
– The use of ecogeochemical tracers to quantify food web dynamics in the Northwater region

Douglas Causey, Ashley Stanek, Kate Sheehan & Kurt Burnham
– Evidence for increasingly rapid destabilization of coastal Arctic foodwebs

Jean-Éric Tremblay, Simon Bélanger, Marjolaine Blais, Michel Gosselin & Christian Marchese
– Is the North Water still a biologically productive oasis?

Eva Friis Møller, Mette Dalgaard Agersted, Kasper Lambert Johansen, Frank Rigét & Anders Mosbech
– Why is the North Water Polynya Region such an important breeding area for little auks?

Mathieu LeBlanc & Louis Fortier
– Importance in the timing of the North Water (NOW) Polynya formation for polar cod Boreogadus saida and its zooplankton prey

Jakob Thyrring & Mikael Kristian Sejr
– Identifying climatic drivers of range expansion of a boreal species into the North Water

Posters & Movies

Natascha Kumar, Jaime L. Toney, Sofia Ribeiro & Julien Plancq
– Climate and environmental change over the past 4000 years in a High Arctic polynya – a biomarker approach

Karl Brix Zinglersen, Martin Jakobsson & Jukka Wagnholt
– Update and detailing of the IBCAO bathymetry model over Greenland

Astrid Andersen, Janne Flora, Kasper Lambert Johansen, Mads Peter Heide-Jørgensen & Anders Mosbech
– Piniariarneq

Populations of Marine mammals, birds and fish

Mads Peter Heide-Jørgensen
– Overview of the populations and assessing sustainability of current use of living ressources and new potentials

Rikke Guldborg Hansen, Mikkel Sinding, Nynne Hjort Lemming, Aqqalu Rosing-Asvid & Mads Peter Heide-Jørgensen
– A comparison of the abundance and distribution of marine mammals wintering in the North Water Polynya and the North East Water Polynya – Is it NOW or NEW?

Eva Garde, Signe Jung-Madsen, Susanne Ditlevsen, Rikke G. Hansen, Karl Brix Zinglersen & Mads Peter Heide-Jørgensen
– The Walrus in Smith Sound

Anders Mosbech, Kasper L. Johansen, Christine Cuyler, Morten Frederiksen, Jannie Fries Linnebjerg, Peter Lyngs & Flemming Merkel
– Little auk and thick-billed murre in the NOW Polynya

Kurt K. Burnham, Jennifer L. Burnham & Bridger W. Konkel
– Status of peregrine falcon and gyrfalcon populations in northwest Greenland

Jesper Boje
– Fisheries in the northern Baffin Bay and its future potential

Kasper Lambert Johansen, Janne Flora, Astrid Oberborbeck Andersen, Mads Peter Heide-Jørgensen & Anders Mosbech
– The Piniariarneq Project: Inughuit hunters map their important hunting areas

Parnuna Egede
– Interactive atlas of Inuit knowledge on the Pikialasorsuaq ecosystem, and past and present use of living resources

Human stressors

David Boertmann, Tom Christensen & Kasper L. Johansen
– Anthropogenic stressors in the NOW – today and in the future

Mette Frost
– Modelling oil spill trajectories in Melville Bay and the North Water Polynya

Line A. Kyhn, Danuta M. Wisniewska, Jakob Tougaard, Malene Simon, Kristian Beedholm, Anders Mosbech & Peter T. Madsen
– Seismic surveys in Baffin Bay and the Greenland regulation

Rune Dietz, Anders Mosbech, Janne Flora & Igor Eulaers
– How the traditional lifestyle and diet in the Northwater region are challenged by long-range pollution

Jennifer Burnham, Kurt Burnham, Matthew Chumchal, Jeffrey Johnson & Jeffrey Welker
– Status of mercury concentration in twenty-four bird species in northwest Greenland

Erin Keenan & Martine Giangioppi
– Tools for Marine Conservation Planning in the Eastern Canadian Arctic

ABSTRACTS (Alphabetical order of first author's last name)

Piniariarneq

Astrid Andersen[1], Janne Flora[2], Kasper Lambert Johansen[2], Mads Peter Heide-Jørgensen[3] & Anders Mosbech[2]

[1] *Aalborg University*
[2] *Aarhus University, Department of Bioscience, Denmark*
[3] *Greenland Institute of Natural Resources, Greenland*

Piniariarneq (hunting trip) is a shortfilm recorded by 17 occupational hunters in Avanersuaq (northwest Greenland). In May 2015 hunters from Qaanaaq and Savissivik agreed to participate in a 12 month long interdisciplinary collaborative project mapping their hunting routes and seasonal use of the landscape. Using handheld GPSes the hunters tracked their routes and registered animals they observed or caught. In addition to this, they took photographs and recorded video footage of their activities. In this shortfilm, consisting of different hunting scenarios, the hunters reveal to us how hunting is underpinned by specific skills and techniques, and is integral to everyday life in Avanersuaq today.

Film recorded by: Olennguaq Kristensen, Markus Hansen, Mads Ole Kristiansen, Tobias Simigaq, Mamarut Kristiansen, Odaq Tivnaaq, Qillaq Danielsen, Thomas Qujaukitsoq, Ilannguaq Qaerngaaq, K'ulutana Kvist, Aaqqiunnguaq Qaerngaaq, Avigiaq Petersen, Storm Odaq, Niels Miunge, Kristian Eipe, Minik Larsen & Naimanngitsoq Kristiansen

Editing: Dennis Ingemann. Produced by: Astrid Andersen & Janne Flora

Historical and archaeological records as proxies for the dynamics of the North Water ecosystem

Martin Appelt, Bjarne Grønnow & Kirsten Hastrup

Natural History Museum of Denmark, Denmark

The dynamics of the North Water ecosystem may be better understood if we incorporate human presence in the analysis. In this contribution we want to highlight how traces of human presence in prehistoric times as well as more recent written histories may actually serve as proxies for upheavals in the ecosystem that may not be proven otherwise. Furthermore, through particular cases we aim at showing how social, political, or economic changes are not only responses to environmental changes but potential drivers of change in their own right. Such comprehensive view of a socio-ecological system may lead us towards a more satisfying discussion of present and future developments in the North Water area – so deeply marked by the Anthropocene.

The North Water Polynya sea ice environment – a review of physical processes and biological implications

D.G. Barber & C.J. Mundy

Natural History Museum of Denmark, Denmark

The NOW Polynya is a unique aspect of the Arctic environment created by consistent patterns of sea ice dynamic the thermodynamic processes. It is formed through a combination of processes operating across the ocean-sea ice-atmosphere (OSA) interface, including the southerly transported Arctic Ocean waters, strong northerly winds, and the export of sea ice from the Arctic Ocean. These three processes combine to form ice arches in Smith Sound and Nares Strait. These ice arches holds back the motion of southward flowing sea ice and icebergs from the Lincoln Sea and Nares Strait, allowing the northerly winds to push ice out into Baffin Bay, expanding the NOW Polynya southward. Due to its large area of open water and availability of light deep into the water column, the NOW Polynya is one of the most biologically productive regions in the Arctic. Its short trophic system consists of; primary producers, micro- and meiofauna, birds, whales, fish, and polar bears. The spring phytoplankton bloom attracts a diverse population of birds, whales, and seals, often times the home of many during winter and provides key migratory paths during the spring. As our understanding of the overall changing Arctic system continues to expand, so must our understanding of how regional dynamics link to global climate change and variability, and thus the effect future conditions of NOW will have on the people who make use of these marine resources.

Anthropogenic stressors in the NOW – today and in the future

David Boertmann, Tom Christensen & Kasper L. Johansen

Aarhus University, Department of Bioscience, Denmark

This presentation will give an overview of present days anthropogenic stressors acting in the NOW, such as hunting and fishing, local and long transported contaminants, shipping, mineral and petroleum exploration. We will risk our necks and predict how these stressors will develop primarily in light of the climate changes. For example will reduced sea ice facilitate shipping – both in transit and with calls on coasts in the area e.g. at new mining sites – with increased risk of oil spills and high noise levels in the water column. Changes in distribution of flora and fauna will affect the status of designated important biodiversity areas in the region and current nature conservation measures and environmental regulation of human activities will probably not apply to the future situation. One way of adapting to the changes is through ecosystem based management including monitoring programs.

Fisheries in the northern Baffin Bay and its future potential

Jesper Boje

DTU Aqua – National Institute of Aquatic Sciences, Denmark
Greenland Institute of Natural Resources, Greenland

Commercial fishery in the northern part of Baffin Bay is presently small and only a directed fishery towards Greenland halibut takes place on the deeper slopes of the northern basin. The species distribution of Greenland halibut extends more northerly but fishery at those latitudes is only for local consumption. Polar cod is another species in the area fished for local consumption and also used for longline bait. Given the present changes in the temperature regime in Greenland waters the abundance of Greenland halibut might increase in the area and other fishery scenarios can therefore be foreseen in the near future. Cod is presently moving its distribution more northerly into the Uummannaq and Upernavik areas and is a likely candidate for a future fishery in northern Baffin Bay. Pelagic fish species such as capelin and sandeel might also be available for a future fishery, while herring and mackerel are unlikely to move that northerly within the near future.

Status of peregrine falcon and gyrfalcon populations in northwest Greenland

Kurt K. Burnham[1], Jennifer L. Burnham[2] & Bridger W. Konkel[1]

[1] *High Arctic Institute, USA*
[2] *Augustana College, Department of Geography, USA*

Recent changes in climate have led to latitudinal range shifts in avian species throughout many areas of the world. In the Arctic, similar patterns have begun to emerge, with species once occurring only in the Low Arctic now becoming regular visitors or breeders in the High Arctic. As a result, species which occupy overlapping niches are now competing for both nesting sites and prey. For over 650 years Gyrfalcons *Falco rusticolus* have been regular breeders in the High Arctic of northwest Greenland. More recently (within the past 75 years), Peregrine Falcons *F. peregrinus tundrius* have extended their breeding range northward into this same area and now breed on an annual basis. From 1993 to 2016 surveys for nesting Gyrfalcons and Peregrines occurred along 750 km of coastline in the Pituffik (Thule) area of northwest Greenland. During this period 98 nesting attempts were made by Gyrfalcons at 21 territories and Peregrines made 105 nesting attempts at 15 different territories. The number of occupied sites varied annually, with a maximum of eight for Gyrfalcons in 2002, 2005, and 2008 and twelve for Peregrines in 2016. The Gyrfalcon population appears stable over this 24 year period while the Peregrine population has grown, with the number of occupied sites doubling in the past six years. Of the 21 territories where Gyrfalcons were initially found nesting, Peregrines have subsequently occupied four. Should the Peregrine population continue to grow at the current rate there is little doubt that increased interspecific competition for limited nest sites will occur, leading to a possible decrease in the Gyrfalcon population in northwest Greenland.

Status of mercury concentration in twenty-four bird species in northwest Greenland

Jennifer Burnham[1], Kurt Burnham[2], Matthew Chumchal[3], Jeffrey Johnson[4] & Jeffrey Welker[5]

[1] *Augustana College, Department of Geography, USA*
[2] *High Arctic Institute, USA*
[3] *Texas Christian University, Department of Biology, USA*
[4] *University of North Texas, Department of Biological Sciences, USA*
[5] *University of Alaska, Biological Sciences, USA*

Birds are useful bioindicators of environmental contamination around the globe, but avian studies in the High Arctic have been primarily limited to a small number of abundant species. This study was designed to assess short-term, locally-acquired mercury (Hg) concentrations across both abundant and rare marine and terrestrial avian species in northwest Greenland using non-lethal blood sampling. Blood was sampled from twenty-four migratory avian species (n = 625) over a three year period (2010–2012) along a 750 km section of coastline on the eastern edge of the North Water Polynya in the vicinity of Thule Air Base (77° N, 69° W). Whole blood samples were analyzed for total Hg along with $\delta^{13}C$ and $\delta^{15}N$ to estimate food web position. A significant positive correlation was observed between mean Hg concentrations in blood and trophic position for both adults and juveniles, with mean concentrations of Hg in adults ranging from 11.4 to 1164 ng/g wet weight. Toxicity benchmarks for Hg concentrations in blood are rare for the studied species in the High Arctic, but based on research at lower latitudes, thirteen species examined in this study may be at low risk for Hg toxicity (individuals with Hg concentrations between 200–1000 ng/g ww) while individual peregrine falcons (*Falco peregrinus*), thick-billed murres (*Uria lomvia*), and black guillemots (*Cepphus grylle*) had concentrations suggesting they may be at medium risk (Hg concentrations between 1000–3000 ng/g ww). Shorebirds had proportionally higher concentrations of Hg than expected and may warrant further study. This study provides a comprehensive dataset of Hg concentrations in avian blood for two dozen High Arctic breeding species and provides some of the first data on Hg concentrations in blood for several uncommon arctic avian species, effectively establishing a baseline from which future studies can be compared.

Evidence for increasingly rapid destabilization of coastal Arctic foodwebs

Douglas Causey[1, 2], Ashley Stanek[2], Kate Sheehan[3] & Kurt Burnham[4]

[1] *Department of Fisheries, College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, USA*
[2] *Department of Biological Sciences, University of Alaska Anchorage, USA*[3] *Scripps Institute of Oceanography, UC San Diego, USA*
[4] *High Arctic Institute, USA*

Understanding the complex dynamics of environmental change in northern latitudes is particularly critical for Arctic coastal communities, which are at the interface between land and sea. Coastal marine foodwebs are more complex and interconnected—even in the High Arctic—by comparison to those found in adjacent terrestrial and offshore marine ecosystems. Quantitative assessment of marine foodweb structure and dynamics is challenging given the difficulty in direct sampling of organisms in the water column, particularly so in Arctic regions. We utilize instead indirect methods that allow reconstruction of foodweb structure and entropic stability within a broad range of spatial and temporal scales using birds as proxy indicators of change. Avian communities of marine and terrestrial Arctic environments represent a broad spectrum of trophic levels, from herbivores, planktivores, insectivores, nearshore and offshore fish, even other bird species. We have been reconstructing the foodweb ecology using stable isotopes ($\delta^{13}C$, $\delta^{15}N$, $\delta^{34}S$), parasites, and diet reconstruction of contemporaneous coastal bird communities in High Arctic (northwest Greenland) and Low Arctic (western Aleutian Islands, AK). Initial findings indicate that in the past decade Arctic coastal foodwebs are increasingly less predictable with higher structural variance, less complex, simpler trophic structure, and possibly with different species composition. These patterns appear to be similar throughout the Arctic, but with the effect gradient increasing with latitude. We discuss the potential fine-scale implications of change on High Arctic coastal ecosystems and the effect on seasonal breeding populations of marine and terrestrial animals.

Greening the high Arctic : When and how have seabirds transformed the fresh waters of the NOW Polynya?

Thomas A. Davidson[1], Ivan Gonzalez-Bergonzoni[1,6], Kasper Johansen[3], Sebastian Wetterich[2], Hanno Meyer[2], Torben Windirsch[2], Erik Jeppesen[1], Jesper Olsen[5], Frank Landkildehus[1], Astrid Strunk[7], Rune Dietz[3], Igor Eulaers[3], Nicolaj Larsen[7] & Anders Mosbech[3]

[1] *Aarhus University, Department of Bioscience, Arctic Research Centre, Silkeborg, Denmark*
[2] *Geosciences and Periglacial Research, Alfred Wegener Institute, Potsdam, Germany.*
[3] *Aarhus University, Department of Bioscience, Arctic Research Centre, Roskilde, Denmark*
[4] *Department of Environmental and Biological Sciences, University of Eastern Finland, Joensuu, Finland*
[5] *Aarhus University, Department of Physics, Aarhus, Denmark*
[6] *Laboratorio de Etología, Ecología y Evolución, Instituto de Investigaciones Biológicas Clemente Estable, Montevideo, Uruguay*
[7] *Aarhus University, Department of Geoscience, Aarhus, Denmark*

The North Water Polynya (NOW) is host to an exceptionally large number of seabirds, which gather in large colonies over the brief summer months. These birds link marine and terrestrial ecosystems as they rely on the productivity of the marine polynya for their sustenance but use the terrestrial environment as breeding sites. Here, we examine how the little auk (*Alle alle*), alters freshwater and terrestrial ecosystems using stable isotope ratios ($\delta^{15}N$ and $\delta^{13}C$) of freshwater and terrestrial biota, terrestrial vegetation indices and physical–chemical properties, productivity and community structure of fresh waters in catchments with and without little auk colonies. We then examine the long-term patterns of presence, absence and abundance of a range seabirds across the NOW using palaeoecological approaches. Lake sediment core were taken from lakes within little auk colonies on Salva Ø and at Annikitsoq on the Cape York peninsula. Peat cores were extracted at sites with little auk colonies at Søkongdale, Annikitsoq, and Robertson fjord, from Eider duck colonies at Three Sister Bees and Booth Sound and from a thick billed Murre colony on Saunders Island. $\delta^{15}N$ values provided an unequivocal signature of bird arrival at the lake sites, whereas radiometric dating of the basal sample of a peat deposit provides a minimum maximum age. ^{14}C dating of the peat cores suggest that Eider and thick billed mure have a long history of presence in the NOW going back over 5000 years. Whereas the little auk colonies appear the have arrived at the coring sites 4300 years before present, whereas the peat cores are dated to circa 2400 years BP. We discuss how the arrival and abundance of bird colonies may relate to Holocene climate variation and the history of human habitation.

How the traditional lifestyle and diet in the Northwater region are challenged by long-range pollution

Rune Dietz[1], Anders Mosbech[1], Janne Flora[2] & Igor Eulaers[1]

[1] *Aarhus University, Department of Bioscience, Arctic Research Centre, Denmark*
[2] *Department of Anthropology, University of Copenhagen, Denmark*

Despite he remoteness of this region the Inuit population is not independent of processes at lower latitudes. The Avanarsuaq settlements, facing the Northwater (NOW), are characterized by the highest Arctic Mercury (Hg) concentrations, both in wildlife and in Inuit. Analyses of historical samples have revealed that the Hg concentrations have increased almost 20 fold since the industrial start around 1850. The Arctic Inuit populations, and the one at NOW in particular, receive high dietary exposure to Hg due to the importance of traditional diet, thus raising concern for human health. In agreement with previous health assessments performed under the Arctic Monitoring and Assessment Programme we here quantitatively show how the NOW Inuit population is subject of high dietary Hg exposure due to the nature of their traditional food, composing a significant amount of marine seabirds and mammals. Violation of the Provisional Tolerably Yearly Intake of Hg, on average by a factor of 11 consistently over the last 20 years (1993-2013; range: 7-15), as well as transgression of the Provisional Tolerably Monthly Intake of Hg, often by a factor of 6 (range: 2-16), raises a serious health concern. The seasonal variation showing a considerable Hg influx from narwhal consumption during the open water period was also supported by year round pilot study monitoring Hg exposure in male beard hair. The large surplus of Selenium in many wildlife tissues including the mattak of narwhals is however likely to provide the Inuit some protection against high Hg exposure. Traditional Arctic food also contains valuable nutrients and vitamins and has also proven to be healthier than certain Western food products. Reducing human exposure to Hg in the Arctic will depend both on global action to reduce the anthropogenic Hg entering the environment (Minamata Convention) as well as local dietary choices.

The North Water ice bridge shape and life cycle variability and its impact on the physical oceanography

Dany Dumont

Institut des sciences de la mer de Rimouski (ISMER), Université du Québec à Rimouski (UQAR), Québec,
Network of centers of excellence ArcticNet
Regroupement stratégique Québec-Océan

The ice bridge is a striking feature of tremendous significance for the North Water natural and human history. Its formation and stability until its final break-up, in other words its life cycle, is however very difficult to predict on short and long timescales. Multi-decadal observations reveal a strong interannual variability which precludes the diagnosis of clear long monotonous trends. Instead, they reveal that abrupt changes have occurred over the last forty years in the timing and in the shape of the ice arch. Our current knowledge of sea ice dynamics suggests that other such abrupt changes are likely to happen in the future. In an attempt to better understand the factors controlling this variability, results from a close inspection of the landfast ice edge shape and time evolution from ice charts and satellite imagery will be presented and discussed. Potential impacts of the ice bridge variability on the regional physical oceanography will be also be discussed in the light of recent oceanographic data obtained from the ArcticNet Long-Term Ocean Observatory and oceanographic expeditions in the North Water.

Interactive atlas of Inuit knowledge on the Pikialasorsuaq ecosystem, and past and present use of living resources

Parnuna Egede

Inuit Circumpolar Council

An interactive atlas, presenting Inuit knowledge on the North Water Polynya (Pikialasorsuaq in Greenlandic) will be presented. As part of their mandate, the Pikialasorsuaq Commission conducted consultations in Nunavut and northwest Greenland with communities that are closely connected to the Pikialasorsuaq. The Commission interviewed several members from each community, gathering their knowledge on the Pikialasorsuaq and surrounding habitats, the ecosystem, and their past and present use of the living resources. In collaboration with WWF the results have been incorporated into an online, interactive atlas with several GIS layers.

The use of ecogeochemical tracers to quantify food web dynamics in the Northwater region

Igor Eulaers[1], Rune Dietz[1], Gilles Lepoint [2], Jochen Zubrod[2] & Anders Mosbech[1]

[1] *Aarhus University, Department of Bioscience, Denmark*
[2] *MARE Centre, University of Liège, Belgium*
[3] *Institute for Environmental Sciences, University of Koblenz-Landau, Germany*

The Northwater region is a refuge of biological diversity while continued environmental change urges for quantitative assessment of the changing dynamics of its food web and repercussions for the local Inuit depending on it. Our first results include estimates of trophic position (TP) and isotopic niche (IN) for several seabird and marine mammal species sampled in 2015. No IN overlap exists between the seabird and marine mammal species, while within each group competition for resources seems to occur. Three trophic groups among the seabird species can be observed. Common eider (TP=2.56) and little auk (TP=2.82) feed without competition within the lowest group, while an intermediate group was composed by black-legged kittiwake (TP=3.09), black guillemot (TP=3.20) and Brünnich's guillemot (TP=3.15), of which the latter two show considerable IN overlap. Similarly, glaucous gull (TP=3.56) and northern fulmar (TP=3.53) show considerable IN overlap, together constituting the highest trophic seabird group. Positioned at the same TP as glaucous gull and northern fulmar, though dependent on marine carbon sources only, harp (TP=3.58) and hooded seal (TP=3.56) show significant IN overlap, while ringed seal (TP=4.00) and narwhal feed higher up the food web (TP=3.92). Compared to our findings earlier studies on specimens collected between 1998-2000 reported a higher degree of IN overlap among several seabird species and a lack of IN overlap among seal species. As such, over a 15-year time period some conspicuous changes in resource competition are evident, possibly indicating a changing food web due to climate change driven invasive species or species-specific foraging behavior. We will complement the above-mentioned results at the conference by findings on how stable Sulphur isotope data and detailed temporal reconstructions of IN change may provide additional resolution. Finally, we will present on our ongoing efforts to create a mathematical ecological network framework that allows for quantitative assessment of energy, contaminant and disease fluxes in a possibly changing Northwater region.

The winter ecosystem: A gap in our understanding of the North Water

Louis Fortier

Université Laval, Canada

The North Water arguably harbours the richest ecosystems of the Arctic. A review of what is known about some major components of the food web in the polynya emphasizes the want of information on their winter ecology. Although costly and logistically demanding, previous Canadian circum-annual expeditions of the CCGS *Amundsen* in Franklin Bay in 2003-2004 (CASES program) and the Amundsen Gulf in 2007-2008 (CFL program) have had a tremendous impact on our understanding of the winter ecosystem of Arctic seas in general and the Cape Bathurst Polynya in particular. It is proposed that the international Arctic Ocean science community contemplates a scientific overwintering of the *Amundsen* or another icebreaker in the North Water in 2020-2021. Against the background of previous missions, the annual monitoring conducted by ArcticNet since 2004, and proposed international endeavours in Baffin Bay, such an overwintering expedition would help solve several aspects of the mythical North Water. Among many scientific objectives, the circum-annual mission would enable us (1) to inventory the ecosystems of the North Water to buttress the proposal to make the Pikialasorsuaq a Marine Protected Area (including Lancaster Sound); (2) to assess how climate change has affected the regional sea-ice regime and ecosystems relative to our last study of the area in the late 1990's; and (3) to document how the ecosystem services provided to Canadian and Danish Inuit communities will be affected by on-going changes.

Why is the North Water Polynya Region such an important breeding area for little auks?

Eva Friis Møller, Mette Dalgaard Agersted, Kasper Lambert Johansen, Frank Rigét & Anders Mosbech

Aarhus University, Department of Bioscience, Arctic Research Center, Denmark

The North Water Polynya Region in Smith Sound and the Northern Baffin Bay is a highly productive area with great importance to many seabirds and marine mammals. Among them are the little auk, the most abundant seabird in the North Atlantic. Approximately 33 million pairs, or > 80 % of the global population, breed within a range of 325 km along the Greenlandic shores of NOW. In this presentation, we discuss what makes NOW such an important area. We base the discussion on data on oceanography, little auk abundance and their zooplankton prey along the west Greenland coast between 73 and 78.5°N in August 2015 as well as other available data on zooplankton abundance along the west coast of Greenland. Furthermore, we include investigations of little auk chick meals and evaluate the potential impact of little auk foraging on the zooplankton community. Our analyses emphasize the tight linkage between the little auks and *Calanus* during the chick-rearing period. In NOW, little auks were mainly feeding their chicks *Calanus* between 3 and 5 mm, *C. hyperboreus* in particular. As a consequence of the large little auk breeding population, the potential mortality of the older stages of *Calanus* caused by their foraging was significant. The distribution of little auks during the breeding season depends on suitable nesting sites and access to adequate prey, both when the birds first arrive to the breeding area, and later when they feed their chicks. All of which, under current climate conditions make the northern Baffin Bay the major little auk breeding area.

Modelling oil spill trajectories in Melville Bay and the North Water Polynya

Mette Frost

WWF-Denmark

While major oil platform blowouts are rare, the risk of a blowout happening at any future Arctic offshore oil development must be considered before development proceeds, to mitigate risks to wildlife and people dependent on the North Water Polynya. Although no exploration activities are currently underway in the North Water Polynya region, adjacent areas have been licensed for offshore oil and gas exploration. The World Wide Fund for Nature (WWF) has explored the potential trajectory of two hypothetical blowout scenarios to determine the potential consequences for two ecologically important areas; the Melville Bay nature reserve and the adjacent North Water Polynya. The blowout scenarios are modeled for a site within the PITU block off Melville Bay. Modeling is based on a daily flow rate of 3,340 m^3 crude oil. The blowout is presumed to be during open water season (July through October) when drilling operations would take place. A most likely scenario (1-day spill) as well as a worst case scenario (34-day spill) is modeled. Based on a blowout scenario modeled to have occurred on August 27, 2012, the spill trajectory initially heads to the west of the spill site before turning north and oiling sections of the coast of Melville Bay Nature Reserve 12.6 days into the simulation. The trajectory continues to travel northwest along the coast and into the North Water Polynya area, oiling additional shoreline areas including along the settlement of Savissivik, Kap York, Kap Atholl, Kap Parry, and Carey Islands. Floating oil not retained on shore continues to travel westward and southwestward. After 65 days, most of the remaining surface oil is bound in sea ice and moving with the ice currents. At the end of the 120-day simulation, 17,583.2 m^3 of oil (about 15% of the volume spilled) remains on the water surface in Baffin Bay, mostly bound in sea ice.

The Walrus in Smith Sound

Eva Garde[1], Signe Jung-Madsen[1], Susanne Ditlevsen[2], Rikke G. Hansen[1], Karl Brix Zinglersen[1] & Mads Peter Heide-Jørgensen[1]

[1] *Greenland Institute of Natural Resources, Greenland*
[2] *Department of Mathematical Sciences, University of Copenhagen, Denmark*

Investigations of diving behavior of the Atlantic walrus (Odobenus r. rosmarus) in the high Arctic Greenland and Canada are important for understanding vital habits and area utilization of this Arctic benthic feeder. Furthermore, such information along with estimations of annual consumption and carrying capacity of walruses can prove essential in management decisions of this utilized species. Satellite-linked transmitters instrumented on 27 walruses from 2010–2013 provided data for investigations of diving behavior in three predefined main areas: NW Greenland, Smith Sound and NE Canada. Sub-areas within each main area were also categorized. Depths of dives, dive rates, time at depth of dives, haul-out periods and vertical speeds were estimated. Majority of dives targeted depths from 10–100 m, which is also the main distribution of walrus preferred food items. Four dives to depths >500 m are the deepest ever documented for a walrus. Dive rates and time at depth of dives were significantly different between sub-areas ($p<0.0001$), whereas haul-out periods were not ($p=0.072$). Mean vertical speeds to destination dive depths ranged from 0.992 ms-1 (95% CI: 0.763–1.221) –1.756 ms-1 (95% CI: 0.986–2.526). Based on dive rates, time at depths, haul-out and percentage feeding dives Alexandra Fjord and Princess Mary Bay in NE Canada and Carey Island in NW Greenland part of Smith Sound was designated as highly important areas for walrus feeding during summer. Walrus predation on the standing bivalve biomass in NW Greenland (within 5–100 m of depth) was estimated to 3.2% annually based on assessments of mean biomass of walrus preferred prey items. From a simple relationship between available shallow water habitat, current population size (n=2544) and walrus pre-exploitation population sizes it is proposed that the carrying capacity in the Smith Sound region does not exceed 5000 walruses .

A comparison of the abundance and distribution of marine mammals wintering in the North Water Polynya and the North East Water Polynya – Is it NOW or NEW?

Rikke Guldborg Hansen, Mikkel Sinding, Nynne Hjort Lemming, Aqqalu Rosing-Asvid & Mads Peter Heide-Jørgensen

Greenland Institute of Natural Resources, Greenland

Polynyas are known to be an important summering and wintering area for marine mammals and the North Water Polynya (NOW) is known to be the most biologically productive polynya in the whole of the Arctic. The internal factors accounting for the temporal and spatial disposition of the polynya are unambiguous like the timing and force of the wind arriving from the west and the ice bridge that stretches over Kane Basin. Whilst the NOW has been a reliably recurrent and high-production ecosystem for recorded history, the Northeast Water Polynya (NEW), which forms each spring over the continental shelf of Northeast Greenland, is recurring in different sizes between years. A northward coastal current interacts with a persistent shelf ice barrier under which water can flow but that retains ice floes and therefore protects the NEW area from ice advection.

We investigate the abundance and spatial distribution of marine mammals wintering in the NOW and NEW. To determine the abundance of marine mammals in the two polynyas we conducted aerial surveys in April 2014 (NOW) and April 2017 (NEW). Visual aerial surveys involving double observer platforms were conducted over the eastern part of the North Water Polynya in April 2014. Four species of marine mammals were included in strip-census estimation of abundance. Perception bias was addressed using a double-platform survey protocol, a Chapman mark–recapture estimator for whales, seals and walruses (*Odobenus rosmarus*) on ice and a mark–recapture distance sampling estimation technique for walruses in water. Availability bias was addressed by correcting abundance estimates by the percentage of time animals detected in water that were available for detection at the surface. The resulting estimates suggested that 2544 walruses (95 % CI 1513–4279), 6005 bearded seals (*Erignathus barbatus*, 95 % CI 4070–8858), 2324 belugas (*Delphinapterus leucas*, 95 % CI 968–5575) and 3059 narwhals (*Monodon monoceros*, 95 % CI 1760–5316) wintered in the eastern part of the North Water Polynya in April 2014. Visual aerial surveys involving double observer platforms were conducted over the Northeast Water Polynya in April 2017. Two species of marine mammals were included in strip-census estimation of abundance. Abundance estimates of walrus and bowhead whales (*Balaena mysticetus*) are currently being developed and will be presented for the first time at the NOW conference. Marine mammals in high numbers were observed in the NOW whereas the abundance of marine mammals in the NEW were low.

Overview of the populations and assessing sustainability of current use of living ressources and new potentials

Mads Peter Heide-Jørgensen

Greenland Institute of Natural Resources, Greenland

The North Water/Smith Sound is known for its conspicuous numbers of marine mammals and sea birds. Four species of seals, the walrus, the polar bear and three species of whales represent the regular inhabitants of marine mammals in the North Water and its summer extension in Smith Sound. In addition 2-3 boreal whale species occasionally visit Smith Sound in summer. Sea birds in the form of two alcidae are breeding in large numbers on cliffs adjacent to the North Water and 3 species of ducks, 6 species of sea gulls, fulmars and Arctic tern breed on islands and promontories around the North Water. The fish fauna is less well studied but includes important species like polar and arctic cod and Greenland halibut, but also capelin, sculpins and lump suckers are known from the area. Economically the most important species are the ringed seals, the polar bear, the narwhal and the walrus, of which the latter two species are presently the most important. Exploitation of Greenland halibut has only recently become economical importance. Data on population size are trends are only available for four species of marine mammals and two species of birds. Some changes in the marine fauna, likely as a consequence of warming in the Arctic and reduction in sea ice, have been observed in recent decades; including summer presence of minke whales and humpback whales, increased abundance of narwhals on the western and northern parts of Smith Sound, increased catches of Greenland halibut in the eastern part, and scattered occurrence of capelin. Abundance and availability of marine mammals and sea birds in the North Water seems, however, more predictable with lower annual fluctuations than evident in other parts of Greenland.

The Piniariarneq Project: Inughuit hunters map their important hunting areas

Kasper Lambert Johansen[1], Janne Flora[1], Astrid Oberborbeck Andersen[2], Mads Peter Heide-Jørgensen[3] & Anders Mosbech[1]

[1] *Aarhus University, Department of Bioscience, Arctic Research Center, Denmark*
[2] *Aalborg University, Denmark*
[3] *Greenland Institute of Natural Resources, Greenland*

Presently, Greenland is the scene of an extensive mapping of key habitats of important plants and animals, biodiversity hotspots, and ecosystem functioning, the results of which are to inform spatial planning processes to mitigate the effects climate change and an anticipated increased industrialisation of the High Arctic in the near future. Mapping of important resource areas of local, human communities have also been conducted on numerous occasions, but has generally received much less attention, and often results from such efforts are difficult to integrate with biological data. Here, we will present the results of a collaborative GPS tracking project in which seventeen occupational hunters from the NOW region documented their hunting trips during 13 months in 2015-16. The hunters were equipped with a handheld GPS device with a custom-made application (app) named *Piniariarneq* (hunting trip). This app allowed them to record detailed information on individual hunting trips, which beyond the route itself, included means of transportation, the composition of the hunting party, catches and observations of animals, as well as anything else the hunter found relevant to document through geotagged written notes, photographs and video footage. Based on these data, we will show how the hunters' use of the landscape changed through the seasons in 2015-16, highlighting their important resource areas. Data resulting from Piniariarneq are in many respects compatible with spatial biological data, better facilitating integrated analyses and assessments of important areas across traditional disciplinary boundaries. We argue that an approach like Piniariarneq has the potential to contribute to a better integration of local hunting and fishing areas in spatial planning processes, and not least to a better rooting of knowledge production on these matters in the local communities.

Tools for Marine Conservation Planning in the Eastern Canadian Arctic

Erin Keenan & Martine Giangioppi

WWF-Canada, Toronto, Ontario, Canada

As an NGO, WWF cannot decide on the allocation of resources in or management of the Pikialasorsuaq. However, WWF can provide tools to inform that management through the supporting and communicating science, both bio-physical and traditional knowledge. In this talk, we will examine two tools, one already developed, and one in development. The first tool is a digital atlas of the Pikialasorsuaq, cataloguing human uses and ecological information from both the Canadian and Greenlandic sides of the polynya. The atlas is a visualization of existing information about the region and includes data from recent Pikialasorsuaq Commission consultations in Arctic communities, to be used to advance the management of the Pikialasorsuaq. The second tool maps Eastern Canadian Arctic bioregions to support future MPA network development. The map will be developed using MARXAN analysis, integrating spatial scientific information (wildlife distributions, habitat, benthic data, geophysical data, etc.) and traditional and local knowledge (significant cultural areas, hunting areas, etc.) to capture the maximum number of identifiable components of marine biodiversity and culturally significant areas embedded in potential candidate MPAs. This tool can contribute to MPA network development in the Eastern Arctic and inform the development of the future pan-Arctic MPA network. Because of the established significance of the Pikialasorsuaq, it is likely that this area will be identified in the analysis, but the analytical framework will contextualize it in a circumpolar frame.

Climate and environmental change over the past 4000 years in a High Arctic polynya – a biomarker approach

Natascha Kumar[1], Jaime L. Toney[1], Sofia Ribeiro[2] & Julien Plancq[1]

[1] *University of Glasgow, Scotland*
[2] *Geological Survey of Denmark and Greenland, Denmark*

High-resolution, late Holocene marine sediments are rare due to low accumulation and preservation, thus are of great scientific interest for detailed reconstructions of paleoenvironments. There is high potential for these data to be used in climate modelling and to understand rates of environmental change in the recent geologic past. In this study, a continuous (5.4m) sediment core spanning the last 4000 years was obtained from the continental shelf of the North Water Polynya and analyzed for lipid biomarkers. Organic compounds such as lipids are obtained from several sources such as plant leaf waxes and microorganisms and are usually well preserved in marine sediments. While biomarker studies have been performed previously in the Arctic, this study is the first to focus on paleoclimate reconstructions using both marine (e.g., sterols) and terrestrial biomarkers (i.e., *n*-alkanes and hopanes). The presence of *n*-alkanes within the sediment core was identified using gas chromatography and analysed using indices such as the Carbon Preference Index, Average Chain Length and 'portion aquatic' index (Paq) to correlate changes in the concentration of short-, medium- and long-chained alkanes to climatic variations. Sterols were identified in this study, and analyzed using indices such as PIP_{25}. These data are interpreted as indicators in changes of sea ice extent surrounding the polynya and provides insights into warm and cold periods, as well as, nutrient availability to microorganisms. The study identifies globally recognised climatic events such as the Medieval Warm Period and the Little Ice Age that ca. 740-1300 AD and 1350-1850 AD, respectively, highlighting the widespread effect of the events in the Northern Hemisphere. The timing, magnitude and rate of environmental changes associated with these climatic events in the North Water Polynya are investigated in the context of previously published data on early settlements and migrations within high arctic West Greenland and Canada.

Seismic surveys in Baffin Bay and the Greenland regulation

Line A. Kyhn[1], Danuta M. Wisniewska[1], Jakob Tougaard[1], Malene Simon[3], Kristian Beedholm[1], Anders Mosbech[1] & Peter T. Madsen[1]

[1] *Aarhus University, Department of Bioscience, Denmark*
[2] *Hopkins Marine Station, Stanford University, USA*
[3] *Greenland Institute of Natural Resources, Greenland*

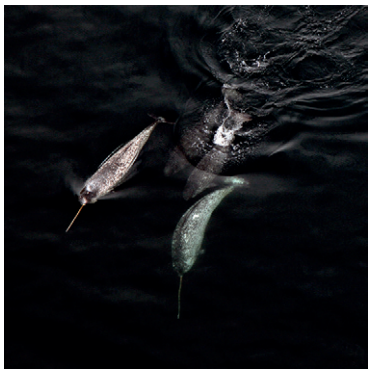
Seismic surveys increasingly operate in deeper Arctic waters with propagation conditions and a marine mammal fauna different from better-studied temperate or shallow-water regions. Therefore we quantified the noise contributions from four concurrent seismic surveys in Baffin Bay, Greenland, to estimate their potential impacts on Arctic marine mammals using calibrated 31 sound recorders. The impact was cumulative as the noise level rose in response to the onset of each survey: On a minute-to-minute scale the sound exposure levels varied with up to 70 dB (20 dB on average), depending on range to the seismic vessel, local bathymetry effects and interference patterns, showing a significant change in the auditory scene for marine mammals. The measured values matched well with pre-season modeling, emphasizing the value of noise modeling in impact assessments, if species-specific responses of focal marine mammals are known. The results of the study is discussed in relation to the current regulation of underwater noise in Greenland with focus on the NOW Polynya.

Importance in the timing of the North Water (NOW) Polynya formation for polar cod *Boreogadus saida* and its zooplankton prey

Mathieu LeBlanc & Louis Fortier

Québec-Océan, Department of Biology, Université Laval, Canada

In arctic marine ecosystems, polar cod (*Boreogadus saida*), the main pelagic forage fish, and zooplankton play a key role by transferring energy from primary producers to top predators and, ultimately, to Inuit communities. In the eastern Canadian Arctic, the North Water (NOW) Polynya is known as a rich environment and an oasis for marine life. The effects of inter-annual variations in the timing of the polynya formation on polar cod and its zooplankton prey populations are, however, poorly documented. In this study, we test the hypothesis that an earlier opening of the polynya and a consequent high primary production increase the abundance and biomass of zooplankton and juvenile polar cod in late summer. Hydroacoustic data were continuously recorded in the NOW Polynya region during ArcticNet cruises from 2004 to 2016 on board the CCGS *Amundsen* using a hull-mounted EK60 multi-frequency echosounder. Pelagic nets were deployed to document the zooplankton and fish assemblages and to validate acoustic echoes. Remote sensing data were used to estimate ice concentration and primary production. This study will provide insights on how zooplankton and polar cod populations may react to a modification of this important polynya as a result of climate warming.



Late Holocene changes in primary production and sea-surface conditions in the North Water Polynya

Audrey Limoges[1], Sofia Ribeiro[2], Kaarina Weckström[2,3] & Guillaume Massé[4]

[1] *Department of Earth Sciences, University of New Brunswick, Canada*
[2] *Department of Glaciology and Climate, Geological Survey of Denmark and Greenland, Denmark*
[3] *Department of Environmental Sciences, University of Helsinki, Finland*
[4] *Takuvik, Department of Biology, CNRS & Université Laval, Canada*

To fully understand the observed climate and ecosystem variability and better predict the effects of climate changes on the ecosystem services the North Water (NOW) Polynya maintains, it is critical to explore the fundamental driving mechanisms that have taken place at time scales considerably longer than the instrumental period. Being the backbone of every aquatic ecosystem's functioning and stability, primary producers provide the first indications of changes in environmental conditions. Studying their skeletal remains can therefore offer valuable insights into past ecosystem dynamics. Here, a long marine sediment core (5.47m length) collected from Smith Sound (700m water depth), at the northern limit of Baffin Bay, was used to investigate changes in primary production and oceanic conditions in the NOW Polynya during the past ca. 4000 years. Concomitant variations of the total abundance and composition of the diatom assemblages are indicative of important modifications in the oceanic conditions, with a significant reduction in the overall primary production after ca. 2500 years BP. A detailed investigation into the environmental significance of these first results will be done using quantitative tools and through comparison with other proxies of primary production (e.g., dinoflagellate cysts).

Little auk and thick-billed murre in the NOW Polynya

Anders Mosbech[1], Kasper L. Johansen[1], Christine Cuyler[2], Morten Frederiksen[1], Jannie Fries Linnebjerg[1,2], Peter Lyngs[3] & Flemming Merkel[2]

[1] *Aarhus University, Department of Bioscience, Arctic Research Center, Denmark*
[2] *Greenland Institute of Natural Resources, Greenland*
[3] *Christiansø Naturvidenskabelige Feltstation, Denmark*

We describe ecological linkages for the little auk and thick-billed murre population in the North Water region and discuss potential future trends based on a comparison with little auk and thick-billed murre colonies elsewhere in the Arctic with different ice conditions and prey availability. The NOW Polynya marine ecosystem is host to the largest seabird populations in Greenland and the area has a diverse seabird assemblage with 14 regular breeders. The little auk and the thick-billed murre are the most abundant of all the seabird species in NOW, and the two species have the largest biomass. While the thick-billed murre has a widespread distribution across the Arctic, the large little auk colonies occur only in the High Arctic near a polynya or other productive marine areas. Although the abundance estimate is uncertain, the little auk population in the NOW region is estimated at 33 mill. pairs, which amounts to more than 80 % of the world population. These huge numbers cause a significant fertilizing impact in the terrestrial environment near the large colonies. The little auks feed their chicks in the colony on High arctic copepods, which are especially large and lipid-rich, and also to some extend rely on the copepods for their own foraging, supplemented with other zooplankton. The high abundance of the large Calanus copepods in NOW during summer is most likely the main cause for the high abundance of little auks in the NOW area. Climate change could change the copepod availability and potentially cause declines in the little auk population. However, some flexibility in little auk prey items has been documented from colonies in East Greenland and Svalbard. With its ecological linkages to the NOW, we argue that the little auk may serve as an important monitoring organism of changes in the NOW ecosystem in the future, and propose parameters which could potentially form part of such a monitoring program. The thick-billed murre colonies in the Greenland part of the NOW region hold about 362,000 birds (count figure) and makes up about 2/3 of the Greenland breeding population. NOW is the only region in Greenland where the thick-billed murre is not declining. The population trend in NOW appears to resemble the stable development observed for colonies in the eastern Canadian Arctic. This is in contrast to declining trends for colonies in the rest of Greenland, Iceland and Svalbard. The causes

of the declines in recent decades are not fully resolved. We assume that historical spring hunting near the colonies in Greenland has had a strong impact on West Greenland colonies south of Upernavik. There has been much lower hunting pressure in the NOW area, which exhibits stable colonies. In recent decades, the overall trend in the Atlantic Arctic colonies seems driven by a combination of harvest pressure and large-scale ecosystem changes occurring in the wintering areas. The thick-billed murres from the NOW area winter primarily off Newfoundland, where conditions seems to be relatively favourable compared to West Greenland and the central and western Atlantic, where many of the declining murre populations winter.

Winter stratification of the High Arctic Inglefield Fjord 2011-2017

Steffen M. Olsen

Danish Meteorological Institute, Denmark

A monitoring program of winter conditions in the high-Arctic Inglefield Fjord was initiated in 2011. The fjord is located in NW Greenland, open to the Baffin Bay at depths above 400m and typically covered by fast ice from December through June. In winter, an area of recurring open water (North Water Polynia) maintained by prevailing northerly winds reaches to the mouth of the fjord. A number of glaciers terminate into the fjord, the most prominent being Tracy and Heilprin. Late-winter surveys and data from ice-tethered seasonal moorings document a persistent Atlantic warm core (AWC) at 300m depth throughout the length of the fjord. Winter properties of the AWC have been remarkably stable with a modest peak in temperature in 2014. More striking is the variability in upper stratification where two distinct modes are observed: 1) A brine enriched mixed-layer only 10-20m thick is formed in the ice-covered part of the fjord. 2) The >100m deep mixed-layer of the off-shore Polynia extends throughout the length of the fjord. These modes impact the formation and growth rate of fast ice and are the primary cause for variations in glacial melt potential. Above the AWC, modified waters result from latent cooling from ice melt and subsequent mixing with the melt water. In addition, a lens of water resting below the mixed layer shows evidence of mixing with a liquid freshwater source, possibly subglacial discharge. We explain the different configurations of the upper stratification accordingly: In years where the Polynia water is anomalously light, modified Atlantic water by glacier interaction is not sufficiently buoyant to destabilize this stratification and Polynia water then occupies the entire fjord. The main driver of change in the fjord is therefore found to be the conditions in the Polynia. Here we observe a pronounced densification and salinification until 2017 of the winter mixed-layer.

The representation of the North Water in coupled ocean and sea ice models

Till Soya Rasmussen[1], Mads Hvid Ribergaard[1], Nicolai Kliem[2] & Eigil Kaas[3]

[1] *Danish Meteorological Institute, Denmark*
[2] *Esnord – Erhvervsskolen Nordsjælland , Denmark*
[3] *University of Copenhagen, Denmark*

The North water is a result of the formation and breakup of sea ice bridges in Nares Strait and wind that moves the sea ice away from the coast. When ice bridges forms in Nares Strait the transport of thick ice from the Arctic Ocean is blocked. Even when the polynya is not open sea ice is thin in the area. This makes it a special area for sea ice physics and very challenging area to model as the current state of the art models are not build to model sea ice without motion. This study utilizes a coupled ocean and sea ice model with the aim of demonstrating the skill of the model system and its capabilities of modeling the polynya. This presentation will focus on the formation of ice bridges and the opening of the North Water. The opening of the polynya will be studied in two seasons. The first is a winter situation where strong winds open the polynya and quickly close it again due to the freezing atmosphere. The second is a summer situation where the polynya remains open thus it allows light intrusion into the upper part of the ocean earlier than what is seen in the rest of Baffin Bay.

Sea ice conditions and primary productivity in the North Water Polynya – the past 4000 years

Sofia Ribeiro

The Geological Survey of Denmark and Greenland, Denmark

In the context of climate change, the future of the North Water Polynya remains uncertain. This is partly because our understanding of its long-term dynamics is very limited (e.g. satellite observations only started a few decades ago). As the ongoing warming and decline in Arctic sea ice cover accelerate, there is a pressing need to look further back in time and decipher the response of the NOW to past climate events that can provide important clues for the future. Marine sediment archives offer an excellent base for reconstructing marine environments, including sea ice conditions and primary productivity. As part of the ICE-ARC project (EU FP7), we investigated a 5.4 meter-long marine sediment record retrieved from a depositional seafloor site in the NOW Polynya region, covering the last ca. 4000 years. We followed a multiproxy approach, including various climate and environmental proxies such as biological indicators (e.g. diatoms), biogeochemical elements (biogenic Silica, organic carbon, Bromine), and sea-ice specific biomarkers (IP_{25}, Triene). Our proxy reconstructions clearly trace the development of sea ice conditions and changes in primary productivity in the polynya during the mid to late-Holocene. The results will be discussed in the light of existing climate records for the northwest Greenland region (e.g. ice core data), as well as historical and archaeological sources.

Climate change, carbon cycling and air-sea exchange

Søren Rysgaard

Aarhus University, Arctic Research Centre, Denmark
Greenland Institute of Natural Resources, Greenland
Centre of Centre for Earth Observation Science at University of Manitoba, Canada

Baffin Bay is one of the most productive marine systems in the northern hemisphere and represents an important connection between the Arctic Ocean and the North Atlantic. Baffin Bay is also an Inuit homeland and an important site for cultural resources and coastal interactions. Climate change is occurring particularly rapidly in the region and long-term, and large-scale integrated studies are needed to understand the cascading effects from physical changes to the environment, ecosystems, and social, economic, and geopolitical conditions. By modulating the fluxes and configuration of ice and freshwater in Baffin Bay, the changing Arctic climate will affect ecosystem services regionally and in the western North Atlantic, as well as globally. Sea ice decline is one of the main causes of the rapid warming of the Arctic, and the flow of carbon from rivers into the Arctic Ocean affects marine processes, nutrients and the air–sea exchange of CO_2. River discharge has increased and the volume of Arctic glaciers and sea ice has radically declined in recent decades. Iceberg calving and accelerated melting and discharge of glaciers and the Greenland Ice Sheet are major contributors to global sea level rise. Changes in weather conditions and in the icescape of Baffin Bay including the release of numerous large icebergs and unpredictable ice hazards pose special challenges on an operational scale to safe transportation in the area.

Identifying climatic drivers of range expansion of a boreal species into the North Water

Jakob Thyrring & Mikael Kristian Sejr

Aarhus University, Department of Bioscience, Arctic Research Centre, Denmark

Climate change is predicted to facilitate a northward expansion of temperate species into the North Water as increasing temperatures and diminished sea ice cover allow species to expand their current distribution limits. Along the west Greenland coast, the temperature blue mussel (*Mytilus edulis*) is a habitat forming species common in the littoral zone. However, adequate data on current distribution patterns has so far been lacking. Here we show that blue mussels at their northernmost limit currently reside on the southern border of the NOW. Being a temperate species, blue mussels could respond to a warmer climate by expanding into the NOW, and increase their abundance, growth rates and fitness. Blue mussels are a dominant ecosystem engineer and their future presence in the NOW may have cascading effects on the ecosystem. Today, knowledge of how "climate" in a broad sense influence distribution and population dynamics of this species is limited. Here, we present data on distribution, abundance, age and mortality as well as physiological measurements of thermal tolerance of intertidal specimens in West Greenland. We correlate our results with climatic data and hereby attempt to identify links between climate drivers and physiology and how this translates into population dynamics and potential future distribution in this region of the Arctic.

Is the North Water still a biologically productive oasis?

Jean-Éric Tremblay[1], Simon Bélanger[2], Marjolaine Blais[3], Michel Gosselin[3] & Christian Marchese[2]

[1] *Québec-Océan and Département de biologie, Université Laval, Canada*
[2] *Université du Québec à Rimouski, 310 Allée des Ursulines, Rimouski, Canada*
[3] *Institut des Sciences de la Mer de Rimouski, 310 Allée des Ursulines, Rimouski, Canada*

A comprehensive investigation of the North Water Polynya (NOW) during the International North Water Polynya study (1997-1999) underscored its very high biological productivity. This high productivity was supported by large inventories of nitrate prior to the spring bloom and augmented by the moderate stirring effect of episodic storms during May (Tremblay *et al.*, 2002b). The large copepod *Calanus hyperboreus* and to a lesser extent *C. glacialis* were able to exploit the high biomass of diatoms and to channel most of the organic matter toward upper trophic echelons. As a result, mass sinking of intact phytoplankton cells did not occur and the bulk of photosynthetically produced carbon was used to support a thriving pelagic food web as well as a build-up of dissolved organic carbon in surface waters. This tight trophic coupling implies that the abundance and fitness of consumers and top predators in the area may be directly proportional to the magnitude of new primary production and, possibly, its seasonal timing. Following the conclusion of the NOW study, annual ArcticNet expeditions performed limited surveys of the polynya with spatial focus on a section extending from Ellesmere Island to Greenland at 76.3 °N. This presentation reports on physical properties, nutrient distributions and the standing stock and productivity of phytoplankton during late summer and fall for the period 1998-2016. The results show strong indications that the NOW recently experienced strong shifts in various indices of productivity, which can be related to a combination of local and remote events as well as a general "atlantification" of the Baffin Bay/Labrador Sea complex. These observations are consistent with remote-sensing estimates of primary production in the upper water column.

Update and detailing of the IBCAO bathymetry model over Greenland

Karl Brix Zinglersen[1], Martin Jakobsson[2] & Jukka Wagnholt[1]

[1] *Department of Environment and Minerals, Greenland Institute of Natural Resources, Greenland*
[2] *Department of Geology, University of Stockholm, Sweden*

The International Bathymetric Chart of the Arctic Ocean, IBCAO, is a widely used seabed topography model in physical oceanography, geology and biology. The model is limited by scarcely available data sources at the time of its compilation. This is also true to the part covering Greenland, particularly the coastal waters and the fjords are most inaccurate, and the problems affect the results of the analyses utilizing the model. In the recent years, a number of international research organizations have carried out scientific bathymetric surveys using multi beam echo sounders across the waters of Greenland, eg. NASA JPL, Alfred Wegener Institute, Stockholm University, WHOI, UiT and others; most of this published recently in the RTopo-2 and BedMachine v3 data sets. The institutions and PI's behind these surveys have kindly contributed their data sets to a new collection, which forms an updated and more detailed bathymetric model covering Greenland, including the area of the North Water Polynia. The collection also include the material previously used in the IBCAO versions as well as older data sets not included at the time. Crowd sourced data from fishery vessels and other local ships are added, as well as track lines from seismic survey vessels in the Baffin Bay, filling in blank areas of the model. The coastline and terrain model, Greenland Mapping Project (GIMP) framing the bathymetry is of greater detail, and thus contributing to a sharper definition of water and terrain as well as an enhanced interpolation from coastline to nearest recorded depths. The resulting model will have a detail of 100m cell size. The authors invite more institutions to contribute with sources of depth data to the updated bathymetric model over Greenland, also for Baffin Bay.

Sponsors:

ᐃᓕᓴᒃ ᑐᓂᐊᕐᓂᒃ ᑲᓇᑕ
OCEANS NORTH CANADA
OCÉANS NORD CANADA

Ministry of Environment and Food of Denmark
Environmental Protection Agency

The NOW Project

THE VELUX FOUNDATIONS
VILLUM FONDEN VELUX FONDEN

CARLSBERG FOUNDATION