Appendix: Speaker's Bios, Abstracts and Materials

Session 1A) Opening Keynote with Lightning Talks

Modern mining impacts & mitigation: An overview of principles and criteria for environmental protection in Arctic mining with a focus on the marine environment.

Speaker: Christian Juncher Jørgensen, Aarhus University

Biography: *Senior Researcher, PhD, Christian Juncher Jørgensen has an educational background in biogeochemistry and has worked both in academia and in the private sector as environmental consultant. Christian's work has included both studies of pollutants in soil, sediment and groundwater systems as well as emissions of gasses and particles in industrial and natural environments both inside and outside the Arctic.*

Abstract:

Modern mining relies on responsible stewardship of environmental resources, balancing the needs of global society, local community and conservation interests. Failure to effectively manage the potential adverse impacts of mining on these shared resources can result in the deterioration of environmental resources and have adverse consequences for human health.

Mining in the Arctic will inevitably lead to some impacts on ecosystem functions in the physical environment where mining activities occur. Public acceptance of where, when and for how long a given impact may be tolerated is not an exact science and is often a matter for discussion before an agreement can be made between communities, authorities and mining companies. Mitigation of mining related impacts on local environments often require special consideration on the overall footprint of the mining operations with a focus on both spatial, temporal, ecological and project-specific aspects and dimensions following a combined set of best environmental practices.

The talk will present an overview of most recent principles for the protection of the environment following mineral extraction operations with direct contact marine ecosystems. The talk will include discussion of recent international guidelines and standards on environmental protection illustrated with examples from sensitive Arctic ecosystems.

Link to *Presentation*

Modern mining impacts & mitigation

An overview of principles and criteria for environmental protection in Arctic mining with a focus on the marine environment.

Session 1A: Opening keynote, Christian Juncher Jørgensen, PhD

Outline of themes and topics

1. General principles and requirements for the protection of the environment
2. Impacts and acceptance
3. Operational freedom vs. regulatory constraints
4. Principles of environmental monitoring
5. Rehabilitation and restoration
6. "Let's build a mine" and other examples
7. Mine closure and post-closure considerations
8. Mining impacts on marine ecosystems

AARHUS UNIVERSITY DEPARTMENT OF ECOSCIENCE
ARCTIC MINING WORKSHOP 21 MARCH 2023 | CHRISTIAN JUNCHER JØRGENSEN SENIOR SCIENTIST

Environmental impacts often correlate with scale of operations

Different requirements:

- Waste water
- Fuel storage
- Handling of drilling additives
- other

Overall principles for environmental protection remains the same.

General principles for the protection of the environment

Overarching principles which mining companies are obligated to use

- **The Best Available Technique (BAT): "***the latest stage of development (state of the art) of processes, of facilities or of methods of operation which indicate the practical suitability of a particular measure for limiting discharges, emissions and waste*"
- **Best Environmental Practice (BEP)**: "*the application of the most appropriate combination of environmental control measures and strategies*"
- **Best Practicable Control Technology (BPT):** "*the best technology available for the control of pollutants that is available at a realistic cost and that can be operated under normal operating conditions*"

General requirements for the protection of the environment

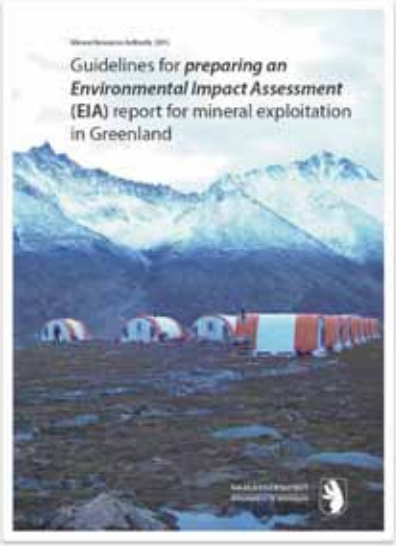
Full scale operations require an in-depth Environmental Impact Assessment (EIA):

- EIA-report for public hearing and political approval

Scope of EIA-assessment for full scale operations

- identify, predict, describe, assess and communicate potential environmental impacts of a proposed mining project from all sources and in all phases
  - Construction
  - Operation
  - Closure
  - Postclosure
- cover the entire area that is affected by the project.
- present mitigation measures to the identified impacts
- include all aspects in relation to nature, wildlife and public health regarding exposure to hazardous substances
- based on environment baseline studies typically covering 2-3 years before onset of construction

Greenland guidelines for describing environmental impacts



For Greenland, specific guidelines exist which are based on international best practice and international standards.

Example from EIA-guidelines (2015)

Discharges/emissions from power plants, fuel combustion plants, incineration plants, process plants and others shall as a main rule comply with EU standards (EU Directive on Industrial Emissions – IE Directive). US or DK standards shall be used if EU standards are not available. Other standards may be used, if they according to BAT, BET and BPT represent a better solution

International guidelines & environmental impacts


11.4.2006 EN Official Journal of the European Union L 102/15

DIRECTIVE 2006/21/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 15 March 2006
on the management of waste from extractive industries and amending Directive 2004/35/EC

JRC SCIENCE FOR POLICY REPORT

Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries

in accordance with Directive 2006/21/EC


GLOBAL INDUSTRY STANDARD ON TAILINGS MANAGEMENT

ICMM UN PRI

link

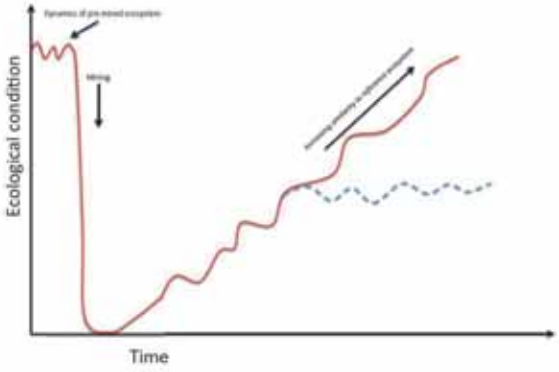
Other leading practice handbooks for sustainable mining

http ding

Impacts & acceptance

Main decision for society and policy makers

- What impacts can be accepted?
- Which risk can be tolerated?



How large a deviation from baseline conditions can be accepted:

Spatial dimension: How large an area can be affected?

Temporal dimension: How long can it last?

Quantitative dimension: How much can be emitted/discharged?

Ecological dimension: Special protection needs (wildlife, fauna, red listed species, breeding grounds, sensitive habitats etc.

Project specific aspects: Site specific (geo)chemical profiles associated with ore processing (physical/chemical), waste disposal, etc.

Post-mining aspects: Need for restoration or full rehabilitation?

Operational freedom vs. regulatory constraints

Fact 1: Mining has unavoidable impacts to the local environment of the mine

Fact 2: Mining companies need operational freedom within permitted limits to be able to work

Fact 3: Objective control measures are needed to show compliance with permits

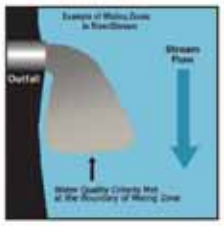
Basis for "Where, when and for how long" is not necessarily an exact science and are often a matter for (some) discussion before an agreement can be made between communities, authorities and mining companies.

International Council on Mining and Metals (ICMM):
***"Industry has a responsibility to be proactive** in contributing practical solutions to the significant environmental challenges facing society. …**adopt practices and approaches that support continuous improvement in environmental performance**…"*

Operational freedom vs. regulatory constraints

Common regulatory tools for footprint control are:

- Contaminant reduction techniques at discrete sources (chemical suppression, dust control, flue gas treatment, water filtration etc.)
- Discharge limits values "at the end of the pipe"
- Buffer zones around point sources
- Mixing zones between point sources and control points
- Water and air quality criteria at defined control points
- On-going environmental monitoring both inside and outside industrial perimeter



Case example – Network of regulatory monitoring points

Example from Giant Mine remediation site, Yellowknife, Canada. Former gold mine (1948-2004).

Gold ore containing arsenopyrite (FeAsS) was roasted to liberate gold forming arsenodioxide gas arsenotrioxide dust

"greatest challenge associated with the remediation of Giant Mine is the safe long-term storage 237,000 t of the arsenic trioxide dust"

https://www.rcaanc-cirnac.gc.ca/eng/1100100027413/1617999134934

Giant Mine Air Program Components

- **Community Program**: Completed at three community monitoring stations (in N'dilo, downtown Yellowknife and at the Yellowknife Cruising Club) to measure and assess air quality in the community and help to ensure the effectiveness of the fence-line air quality program.
- **Fenceline Program** is done using six monitors that are placed in six locations around the perimeter of an active work area and along the southeast shore of the site, at the townsite, the cruising club, and the southeast beach.
- **Activity Specific Program** is established to monitor potential impacts to air quality in the vicinity of workers. Both fixed and mobile monitors are placed near work such as roaster deconstruction or drilling.

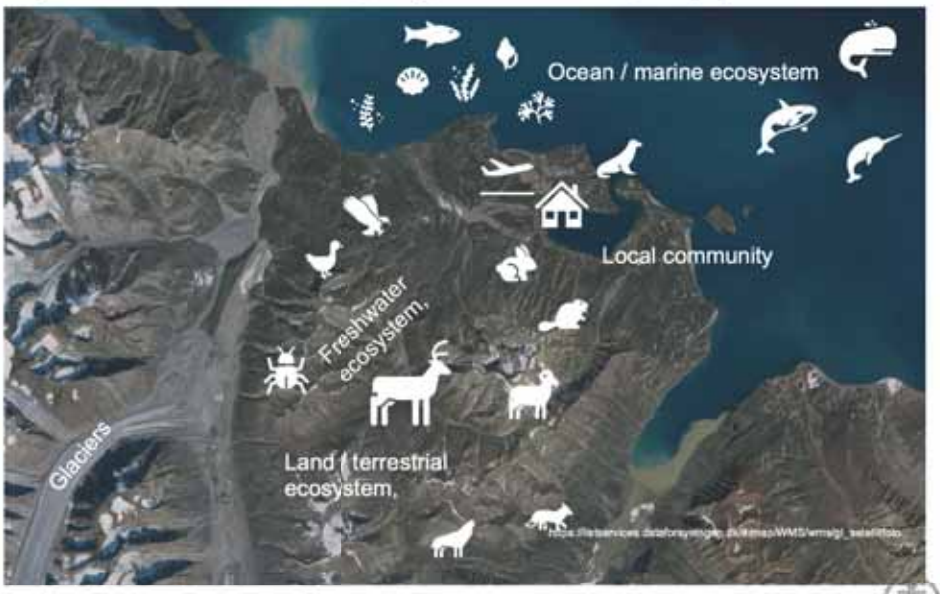
Special case – Industrial perimeter Greenland

Private ownership of land does not exist in Greenland.

Industrial perimeter of mines in Greenland is defined by factors other that "fence-line"

Overall **industrial footprint**, including bufferzones, mixing zones and location of control points are often government by physical **properties of the landscape** the mine is located in.

Hypothetical example based on legacy mine "Blyklippen"



"Blyklippen" – legacy Pb/Zn mine (1957-1963)

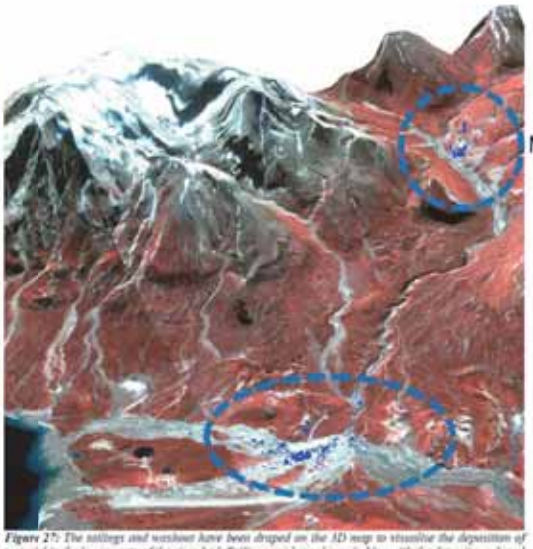


Figure 27: The tailings and washout have been draped on the 3D map to visualise the deposition of material in the lower parts of the river bed. Tailings are here shown in blue with the deposit numbered 1 and the deposition in the lower riverbed as 2.

Let's build a new unobtainium mine

Airport:
Noise/disturbance

Living quarters
Sewage discharge

Port & ships
Underwater noise

Tailings opt. 2
Marine tailings disposal

Processing plant
Stack emissions
Water discharge to ocean
Oil tanks

Migration route of extremely rare red-listed animals

Tailings opt. 1
Acid mine drainage

Mine pit
Blasting/crushing
Dust/noise/light

Road system
Dust emission

Chemical residues
Hazardous waste

Complex assembly of:
- point sources
- diffuse sources
- permanent waste deposits

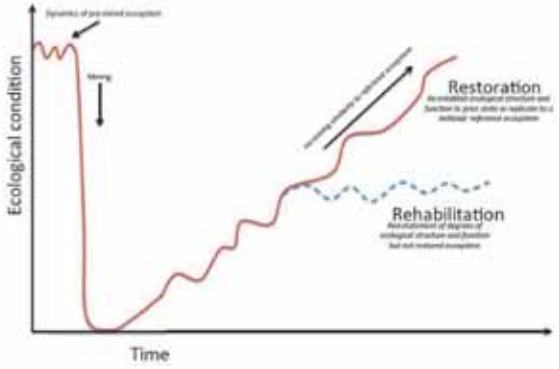
with emission & discharge points located in a sensitive ecosystem and complex terrain with direct impact on the ocean.

Governing principles and rules can be standardized, but concrete solutions requires careful site-specific analysis, planning, control and monitoring including mitigation technique, well-defined buffer zones and long-term monitoring

Mine closure and post-closure conditions

Mine site rehabilitation should be designed to meet three key objectives:

1. the long-term stability and sustainability of the landforms, soils and hydrology of the site
2. the partial or full repair of ecosystem capacity to provide habitats for biota and services for people (WA EPA 2006)
3. the prevention of pollution of the surrounding environment.



With adequate attention and planning successful rehabilitation and/or restoration is achievable for mines, tailings storage facilities and waste rock dumps on land.

Restoration of the marine environment are more complex as most – if not all – impacts are practically irreversible.

Re-mining: Special considerations for future opportunities

Reprocessing – turning 'waste to value'

Reprocessing of tailings following technological advances and/or improving world market value of certain minerals/metals.

Not an option for *deep marine tailings disposal*, so additional careful long-term analysis is needed in this type of scenario.

Summary and concluding remarks

Modern mining relies on responsible stewardship of environmental resources, balancing the needs of global society, local community and conservation interests.

Failure to effectively manage the potential adverse impacts of mining on these shared resources can result in the deterioration of environmental resources and have adverse consequences for human health.

Mining in contact with marine ecosystems require particular attention as impacts are often irreversible.

Marine tailings disposal and seafloor mining has the potential to take a significant toll on the life in the sea which may be difficult – if at all possible – to remedy.

Strengthened dialogue between mining companies, authorities, local stakeholders, consultants, technicians and scientist will lead the way to a more sustainable future mining industry.

Lessons learned from the last century - Mining waste and regulation in Greenland

Speaker: Jens Søndergaard, Senior Research Scientist, Aarhus University

Biography: *Senior Researcher, PhD, Jens Søndergaard studies trace metal cycling in the Arctic, especially mining pollutants and long-transported pollutants such as mercury as a basis for environmental assessments. My research area lies in the interface between environmental chemistry, geochemistry, analytical chemistry and biology.*

What is the Purpose of your Talk?

The purpose of the talk is to give an overview of the main lessons learned from the last century of mining in Greenland, in relation to environmental impact from mining waste and how these lessons have improved the regulation.

Abstract:

Greenland has a long mining history starting with mining of cryolite in 1854 in Ivittuut, South Greenland. However, it was not until the early 1970s that the first environmental studies were conducted. Like many other countries, Greenland has a legacy of long-lasting pollution from former mine sites.

Mining activities at three legacy mine sites in Greenland; the cryolite mine in Ivittuut (1854-1987), the lead-zinc mine in Mestersvig (1956-1963) and the lead-zinc mine in Maarmorilik (1973-1990), resulted in significant pollution of the environment, mostly by lead and zinc. The polluted marine areas at Ivittuut, Mestersvig and Maarmorilik encompassed areas within a distance of at least c. 10-15 km from the mines during the mining periods, and although the pollution has decreased, it can still be measured today.

At Ivittuut, the pollution was predominantly caused by leaching from waste rock placed in the tidal zone along the coastline and between the mine pit and the Arsuk Fjord. At Mestersvig, the pollution was caused by several sources including uncovered tailings deposited on a mountain slope adjacent to a river and exposed to leaching, erosion and dust dispersion; spills and dust dispersion of concentrate during transport and loading; and later collapse of a quay after mine closure. At Maarmorilik, the pollution was mainly caused by dissolution and dispersion of tailings following deposition of tailings into a small partly enclosed sill-fjord. The sill-fjord was unexpectedly affected by seasonal vertical mixing and ocean currents, which caused transport of pollutants across the sill to the larger Qaamarujuk Fjord system. After mine closure, pollution from the tailings ceased due to natural sedimentation covering the tailings. Today, waste rock deposited on the steep mountain slopes is considered the dominant source of pollution at Maarmorilik.

The three legacy mine sites in Greenland have enabled studies of dispersion, bioaccumulation, and toxicological effects of mining pollution under Arctic conditions during the past 50 years. Since the 1970s, monitoring of Greenland mine sites has been performed regularly at operating and closed mines by the authorities and numerous environmental studies have been carried out by research groups. This has provided valuable information for the development of a regulatory system in Greenland with specific

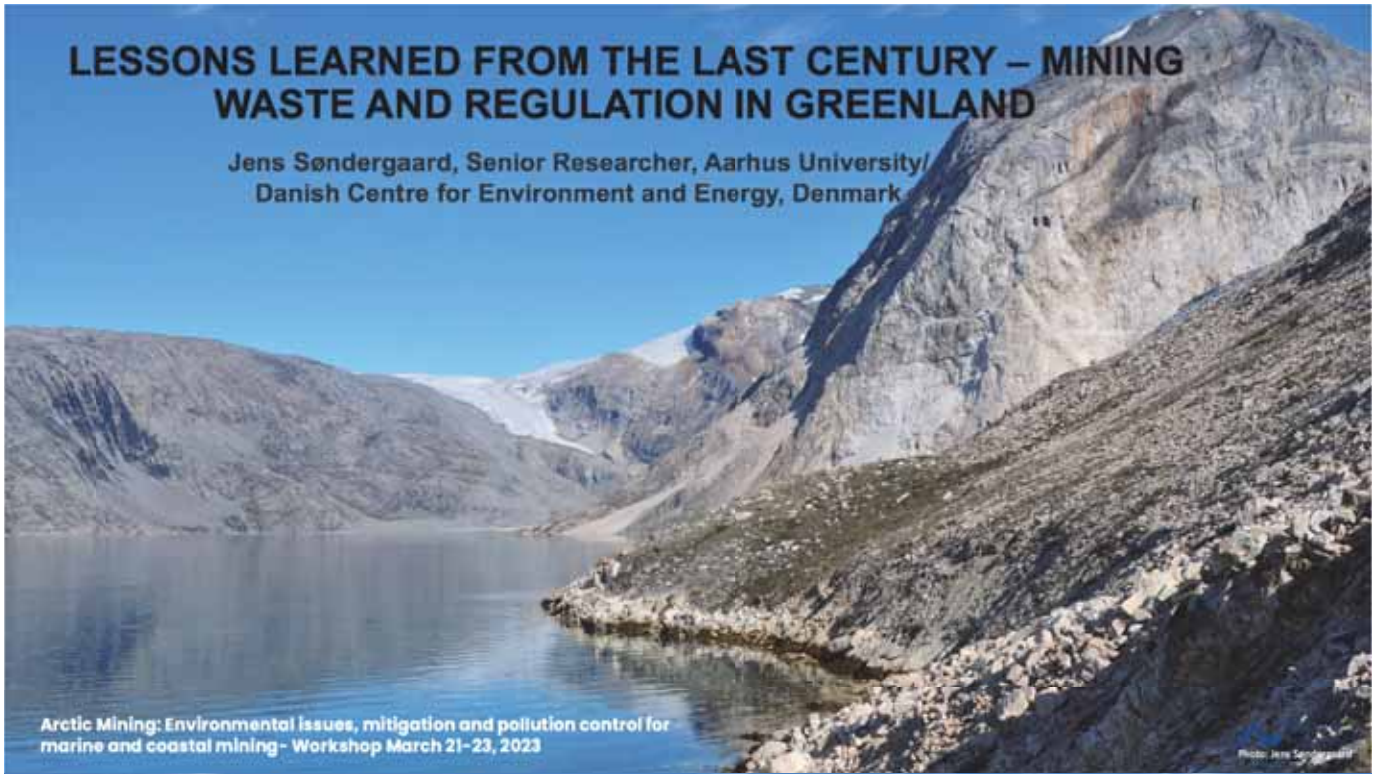
requirements for environmental impact assessments (EIAs), environmental monitoring, use of chemicals etc. to help minimize the impact of new mining activities. Moreover, the knowledge is applied in the 'daily' advisory to the Greenland authorities by the Danish Centre for Environmental and Energy and Greenland Institute for Natural Resources.

The talk will focus on the main environmental issues at the three legacy mine sites in Greenland, the actions taken, the lessons learned, and how these lessons are applied in the current regulatory system to minimize pollution.

Link to *Presentation*

LESSONS LEARNED FROM THE LAST CENTURY – MINING WASTE AND REGULATION IN GREENLAND

Jens Søndergaard, Senior Researcher, Aarhus University/
Danish Centre for Environment and Energy, Denmark

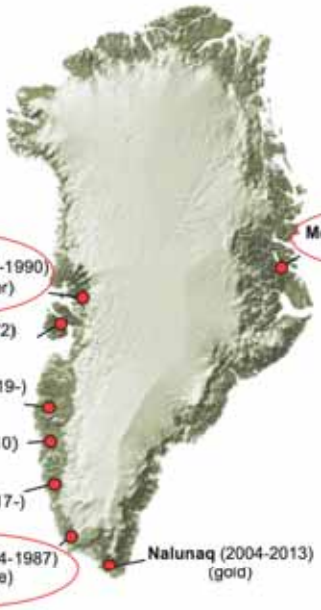


Arctic Mining: Environmental issues, mitigation and pollution control for marine and coastal mining- Workshop March 21-23, 2023

Photo: Jens Søndergaard

CURRENT AND FORMER MINE SITES IN GREENLAND

'LEGACY' MINE SITES



Mestersvig (1956-1963)
(lead-zinc)

Maarmorilik (1973-1990)
(lead-zinc-silver)

Qullissat (1924-1972)
(coal)

White Mountain (2019-)
(anorthosite)

Seqi (2005-2010)
(olivine)

Aappaluttoq (2017-)
(rubies)

Ivittuut (1854-1987)
(cryolite)

Nalunaq (2004-2013)
(gold)

Studies are documented in numerous scientific reports, notes and >50 research publications through the years. Reports are publically available and can be downloaded from https://dce.au.dk

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Greenland legacy mines:

THE CRYOLITE MINE IN IVITTUUT, SOUTH GREENLAND (1854-1987)

- A total of **3.7 mill t cryolite** (Na_3AlF_6) was produced, which was used as solvent in aluminum extraction.

MAIN ENVIRONMENTAL ISSUES

- **Pollution of the Arsuk Fjord** with mainly **lead** and **zinc**.
- Main source of pollution was **waste rock** used for construction along the coastline **leached by tidal water**.
- **Decreasing pollution trend** since the first study in 1982.
- Elevated pollutant levels found in key monitoring species (seaweeds/mussels) within an area up to **ca. 15 km from the mine** during the last monitoring **in 2013**.

The mine pit and mining town in Ivittuut during operation

Link to latest report

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Greenland legacy mines:

THE LEAD-ZINC MINE IN MESTERSVIG, EAST GREENLAND (1956-1963)

- A total of **554,000 t ore** (58,000 t lead; 75,000 t zinc) was produced.

MAIN ENVIRONMENTAL ISSUES

- Pollution of the **terrestrial** and **marine environment** near Mestersvig with mainly **lead** and **zinc** (and some copper, cadmium, barium i.a.).
- Main pollution sources were:
  - **Dispersion of uncovered tailings** deposited downslope from the mine near Tunnelelv (river) ca. 10 km inland.
  - **Dust dispersion of concentrate** along the haul road from the mine to the harbor.
  - **Spills of concentrate from loading** at Nyhavn (harbor) and later **collapse of a quay area**.
- **Decreasing pollution trend** since first study in 1979.
- Elevated pollutant levels found within an area up to **ca. 10 km from the sources** during the last monitoring **in 2014.**


The mine and the tailings deposit near Tunnelelv (river)

Link to latest report

AARHUS UNIVERSITY

Greenland legacy mines:

THE LEAD-ZINC MINE IN MAARMORILIK, WEST GREENLAND (1973-90)

- A total of **11.2 mill. t ore** (590,000 t lead; 2,327,000 t zinc) was produced.

MAIN ENVIRONMENTAL ISSUES

- Pollution of the **marine environment** near Maarmorilik with **lead** and **zinc** (and some cadmium, mercury i.a.)
- Main pollution sources were:
  - **Tailings** deposited in a small sill-fjord (to be elaborated)
  - **Waste rock** deposited on mountain slopes and in the fjord.
  - **Residues of ore and concentrate** from mine/camp
- **Decreasing pollution** since mine closure.
- Elevated pollutant levels found in marine key species within **ca. 12 km from the mine** during the last study in 2017.

The mining town

The mine entrances

Photo: Gert Asmund

Environmental monitoring highlighted the major waste rock dump (above) to be a main source of pollution, so it was (partly) removed during mine closure in 1990.

Link to latest report

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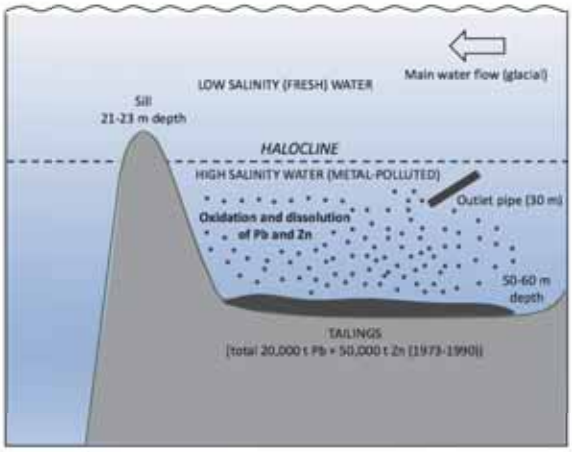
Greenland legacy mines:

SUBMARINE TAILINGS DISPOSAL IN THE A-FJORD, MAARMORILIK

Summer/autumn

Stratification = little outward transport of pollutants



Winter/spring

Vertical mixing some years = major outward flush of pollutants

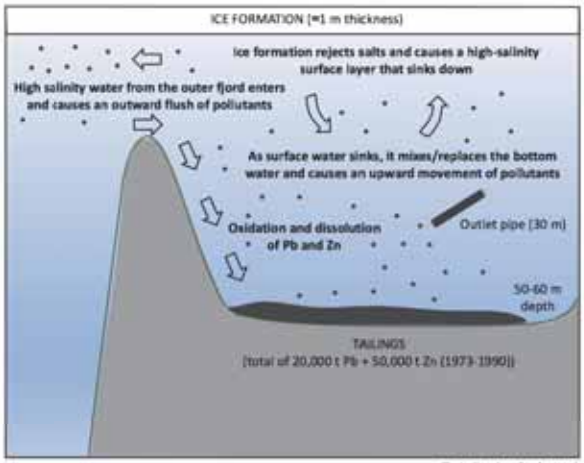


Illustration: Jens Søndergaard

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Greenland legacy mines:

MAIN LESSONS LEARNED & IMPROVED REGULATION

- **Environmental Impact Assessments (EIAs)** needs to be made prior to mining operation following strict guidelines and BAT/BEP principles with involvement by all stakeholders (incl. public hearings) to highlight and minimize impacts **-> Specific EIA guidelines have been developed for GL incl. environmental quality criteria for water and air**
- **Thorough geochemical test work** is needed prior to regulation to assess potential leaching of pollutants using representative waste samples and tests designed to simulate the specific deposition **-> Specific recommendations for geochemical test work in EIAs have been developed for GL**
- **Mine waste deposition** needs to be thoroughly evaluated prior to deposition. Reactive mining waste should not be placed in the tidal zone and places exposed to excessive weathering, risk of floods etc. Deposition on land in areas with permafrost, on steep slopes, or in the sea makes it practically impossible the recover the waste again, if an unexpected pollution occurs **-> Extensive knowledge on arctic mine waste deposition is now part of the knowledge base at DCE/GINR and will be cont. updated**

Link

Link

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Greenland legacy mines:

MAIN LESSONS LEARNED & IMPROVED REGULATION

- Regulation needs to take **seasonal dynamics in environmental conditions in the Arctic** into account. Distinct seasonal dynamics were observed in fjords in Maarmorilik but also in e.g. river water chemistry at Citronen Fjord, North Greenland **-> This is now part of the EIA guidelines and knowledge base at DCE/GINR**
- **Thorough environmental monitoring** is needed to ensure compliance with regulation and for early identification of unexpected environmental issues **-> Specific recommendations for monitoring, sample collection etc. have been developed for GL**
- **A challenge for environmental regulation of mines in the Arctic:** Not two mining projects are similar -> The Arctic pose some unique environmental conditions and challenges -> Numbers of arctic mines are relatively limited -> **A need to share and update knowledge and experiences in mining between Arctic countries to improve regulation (such as this workshop☺)**

Link

Link

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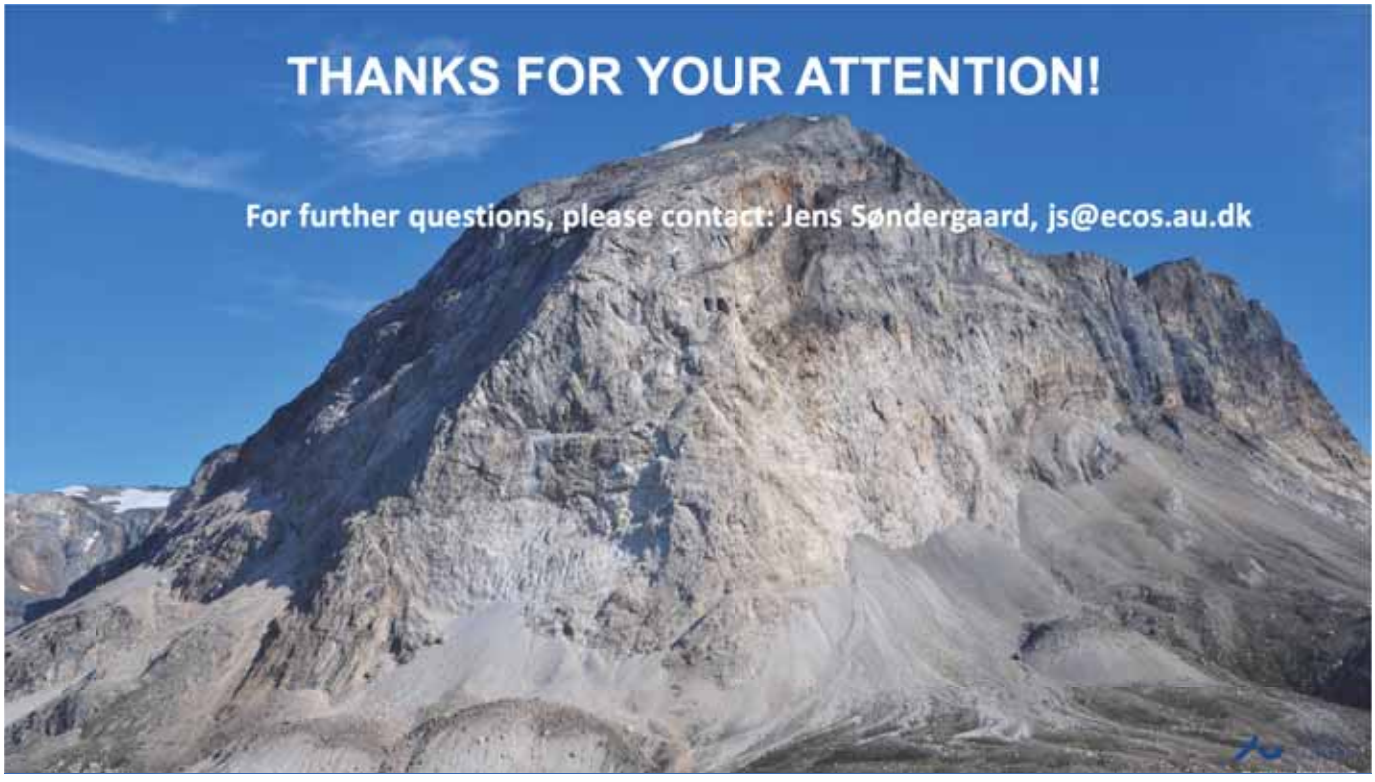


Session 1B) PAME Survey Findings

The PAME Survey: Arctic marine and coastal mining

Speaker: Anders Mosbech, Project Co- Lead, Aarhus University

Biography: *Anders Mosbech has a long experience as project manager for environmental impact studies. He has acted as advisor to the regulatory agencies in the Danish and Greenland governments, participated in international working groups and conducted ecological research on seabirds, geese, muskoxen, marine mammals and vegetation.*

What is the Purpose of your Talk?

The purpose of this talk is to give an overview of the results from the PAME survey of Arctic marine and coastal mines. The survey puts the coastal Arctic mines on the map, and based on a questionnaire to each mine a number of issues in relation to the environment is illustrated across the Arctic.

What is the relevant background and context?

PAME (the Arctic council working group for Protection of the Arctic Marine Environment) initiated this study based on the interest in most Arctic countries for increased mining activity with the minimum impact on the environment and a sustainable coexistence with local communities. It is the hope that the project can identify lessons learned and help improve the environmental performance of future mining in the Arctic.

What do we need to know about methodology and actors?

The project group developed a questionnaire to gather information about each Arctic mine with respect to basics about the mine as well as focus on environmental issues. The questionnaire was approved by the PAME working group and distributed through the national representatives in the PAME working group. The questionnaire was filled out by national experts in each country based on publicly available material like EIA reports. Only mines with discharge (direct or indirect with water or air) to the sea are included in the survey. Mines from US, Canada, Greenland, Norway and Finland are included in the survey.

What are the key learning points you want to share?

The survey provides the backdrop for this workshop; showing the diversity of mines, environmental issues and the diversity of solutions in different countries. These experiences make it possible to reflect on what is the best available environmental solution to each unique mining case to minimize pollution now and in the future. The issues identified for further comparative analysis include:

- Permanent tailing storage facilities
- Shipping and underwater noise

- Monitoring and environmental quality guidelines
- Monitoring and transparency

What are the next steps raised by your talk and/or questions that need to be answered?

It could be discussed what further needs to be done to extract the lessons learned and disseminate the results.

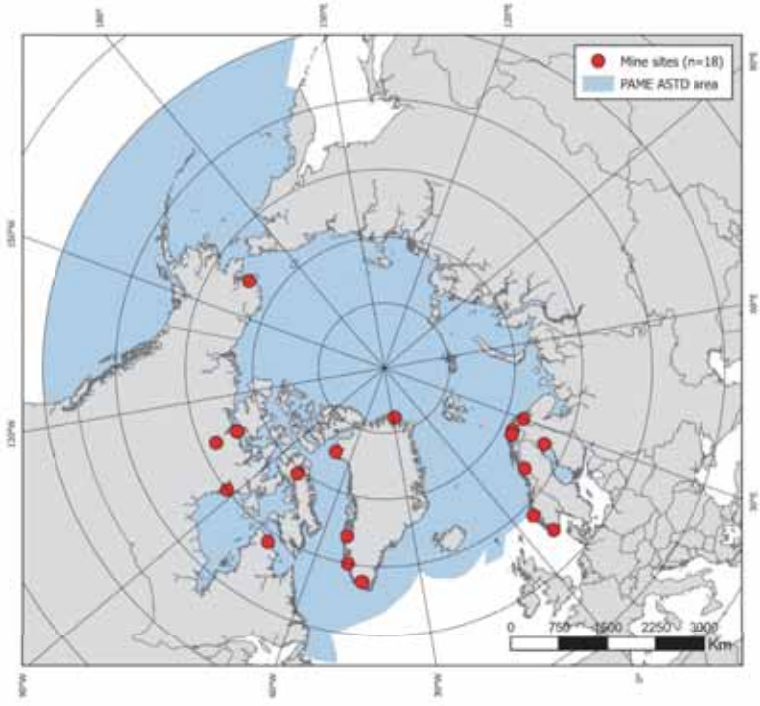
Link to *Presentation*

The PAME survey: Arctic marine and coastal mining - environmental issues

Anders Mosbech

Aarhus University and Danish Centre for Environment and Energy

Arctic Mining Workshop March 21-23, 2023



A questionnaire survey

- Includes approved live projects
- Arctic and marine

Project Team

Maureen Copley (co-lead), Janne Fritt-Rasmussen, Libby Chunyk, David Blockley, Kasper L. Johansen

Contributors

Soile Nieminen, Centre for Economic Development, Transport and the Environment for Kainuu (Kainuu ELY Centre), Finland

Siri Anne Haugland Strand, Norwegian Environmental Agency, Norway

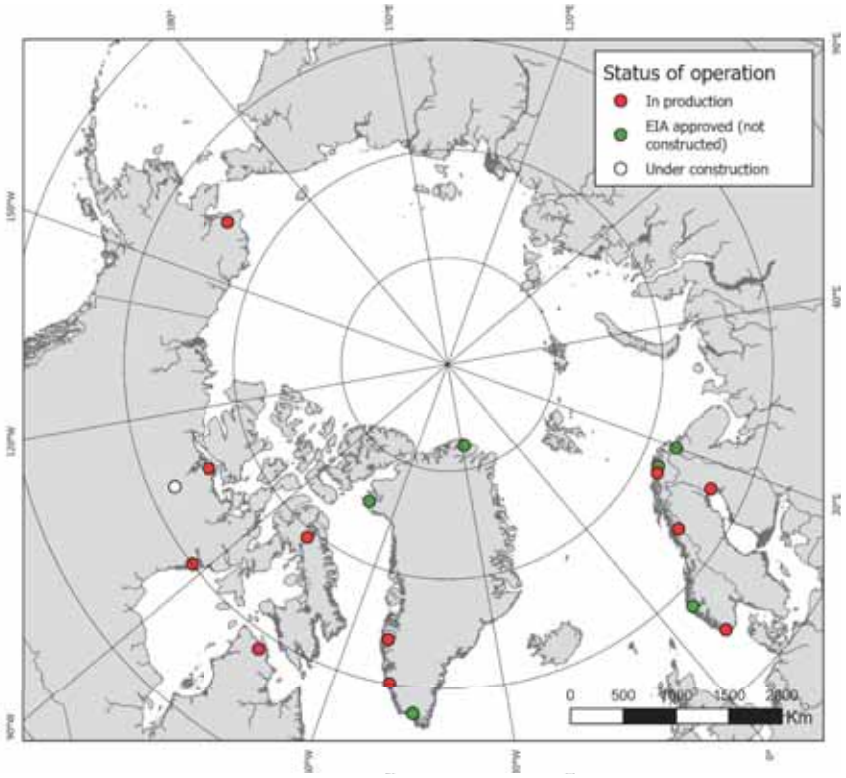
Dennis Thurston, BOEM, USA

And others

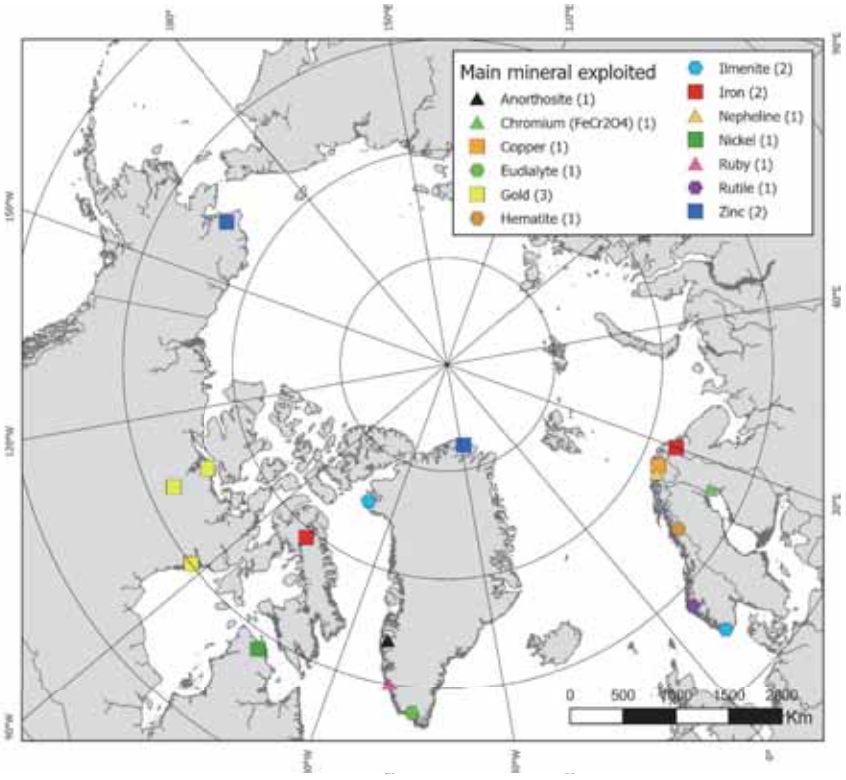
Status of mining operations

11 in production
6 EIA approved
1 under construction

Small scale operations not included e.g. about 60 small scale placer mining oprations in Alaska

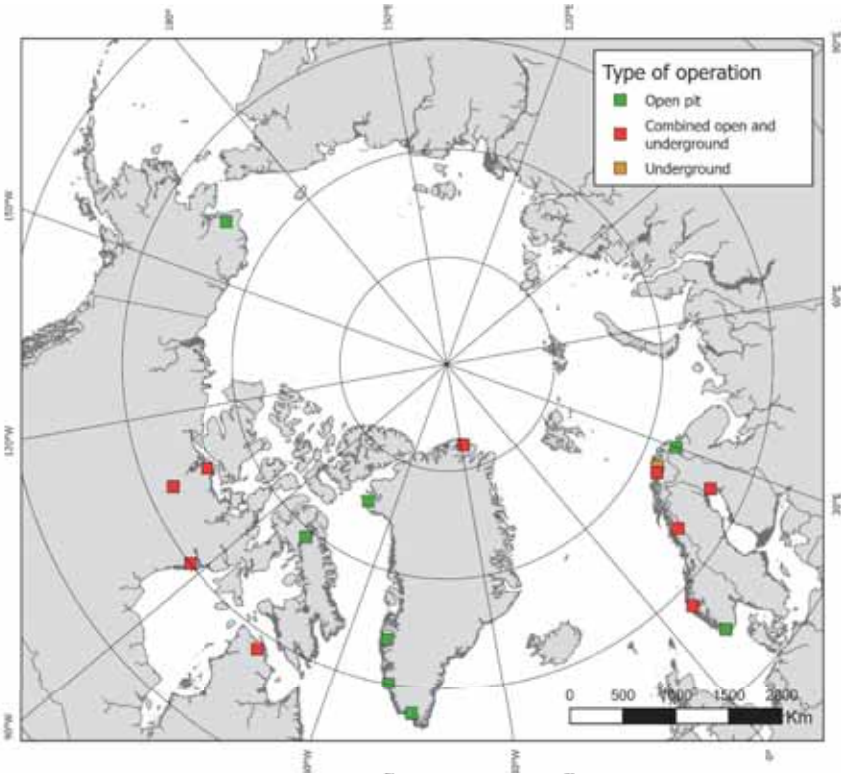


Main minerals exploited

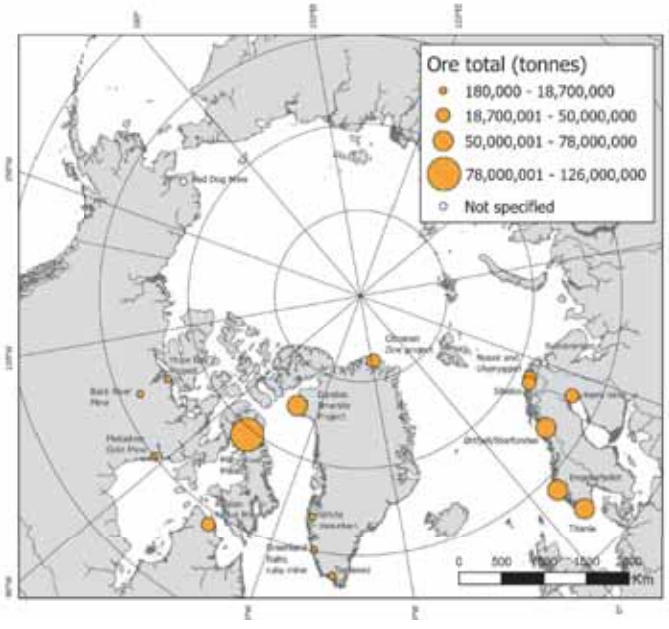


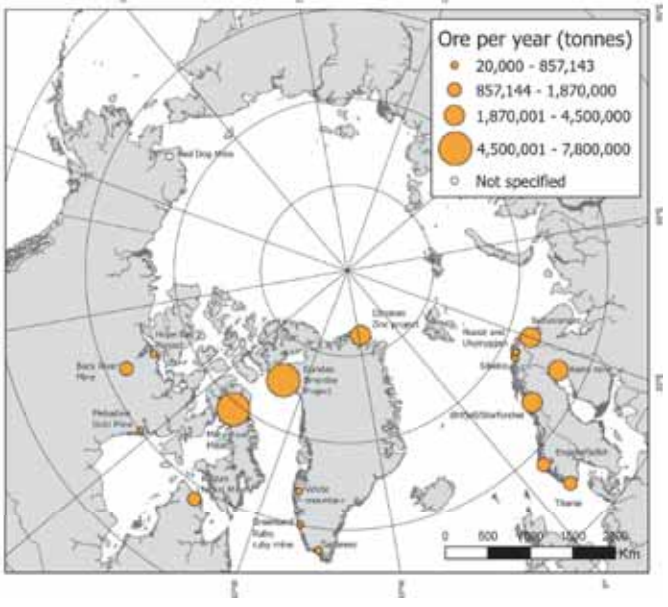
Type of mine operation

8 open pit
9 combined
1 underground

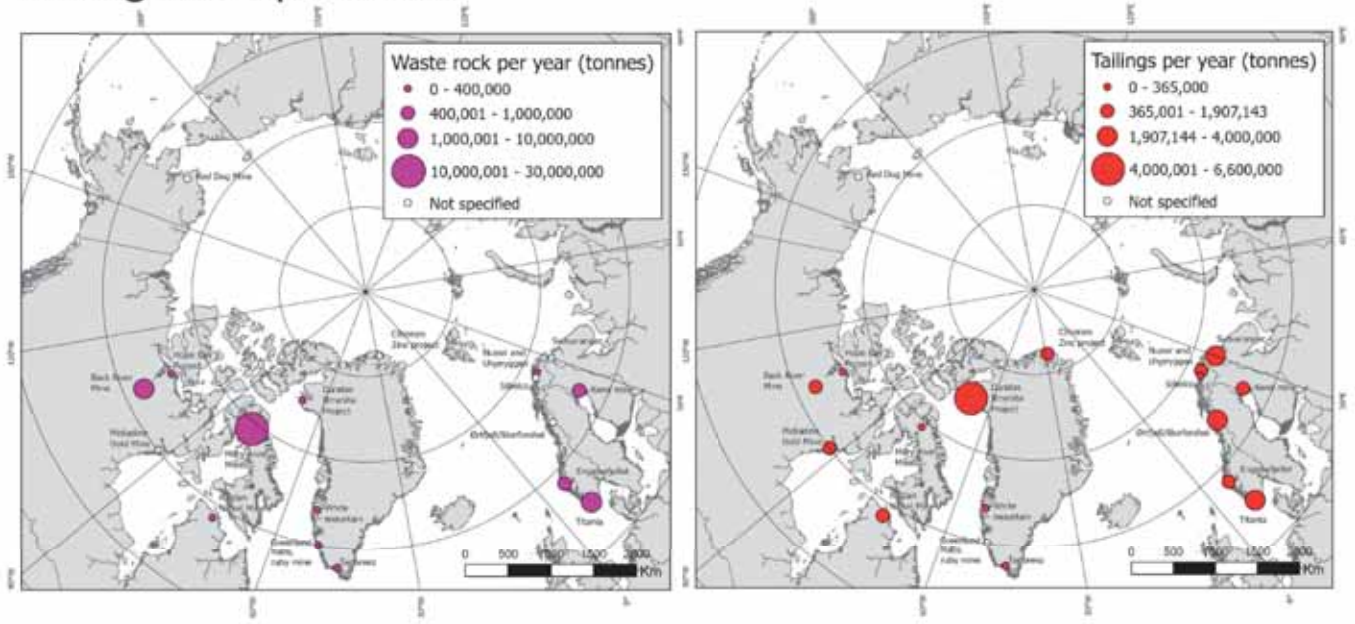


Ore, total and production rate



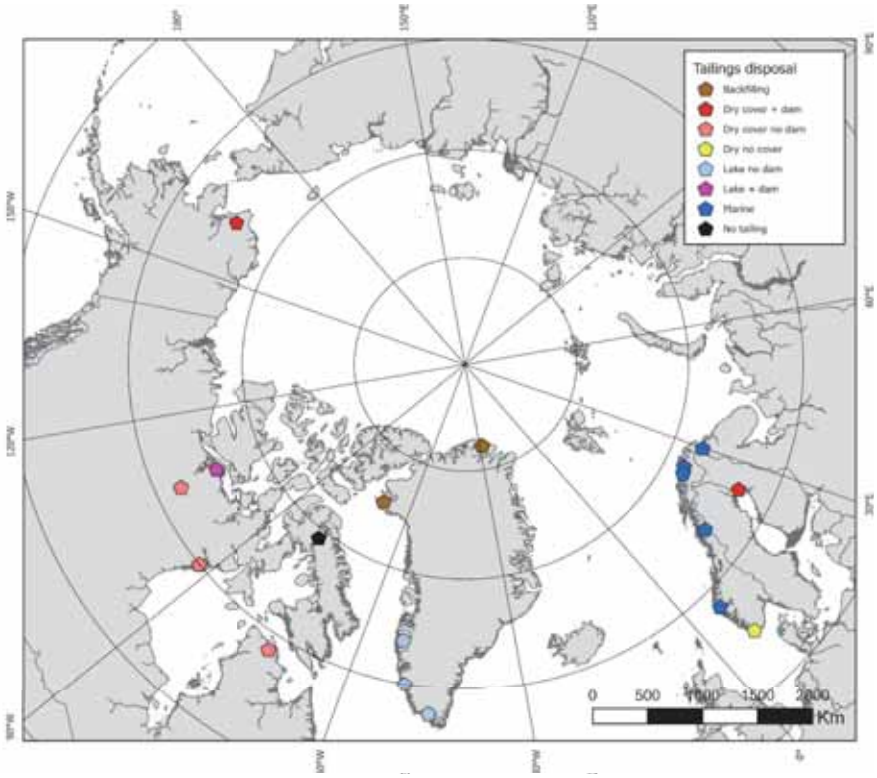


Mining waste produced



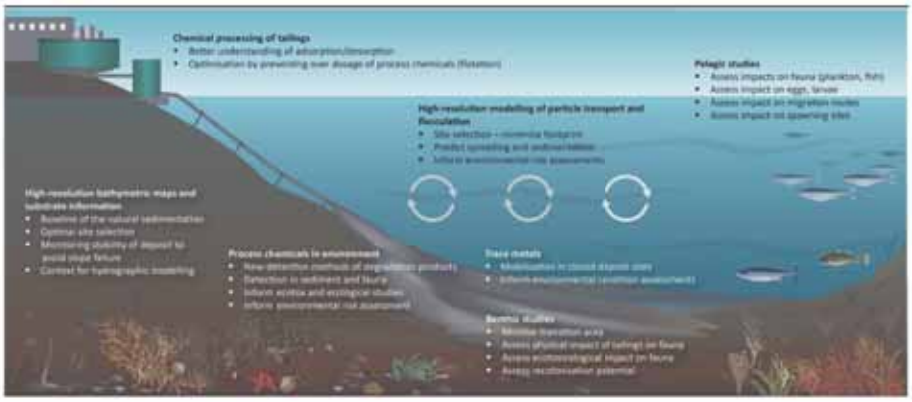
Tailings disposal

Backfilling	2
Dry cover + dam	2
Dry cover no dam	3
Dry no cover	1
Lake no dam	3
Lake + dam	1
Marine	5
No tailing	1



New Research from Norway presented in talk tomorrow

Marine Tailing Disposal: The Norwegian Experience & moderated Q & A. **Hilde Trannum**



Ramirez-Llodra et al. 2022. Marine Pollution Bulletin

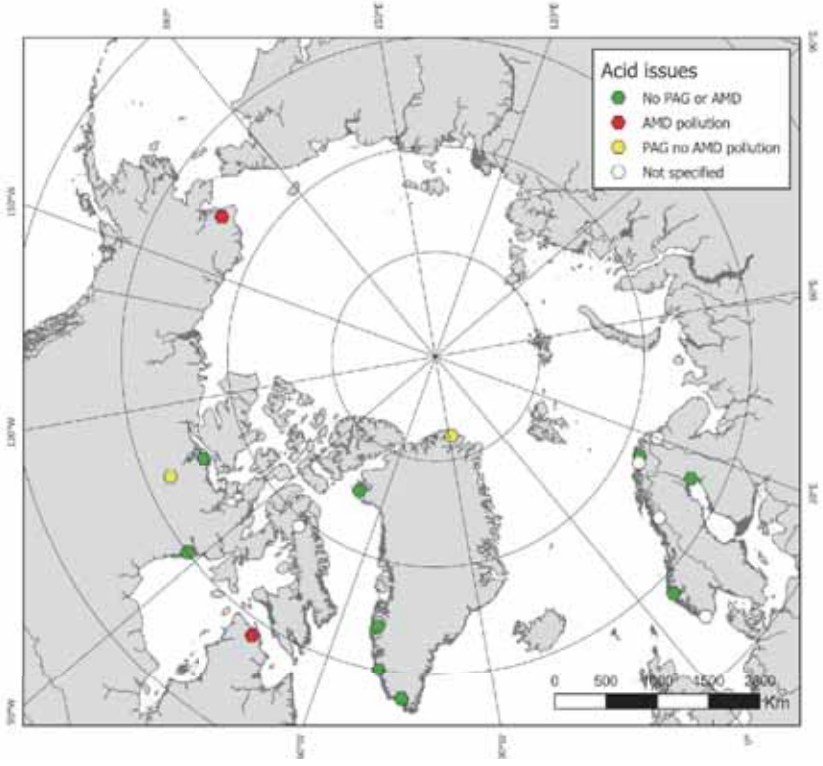
New insights into submarine tailing disposal for a reduced environmental footprint: Lessons learnt from Norwegian fjords

Acid issues

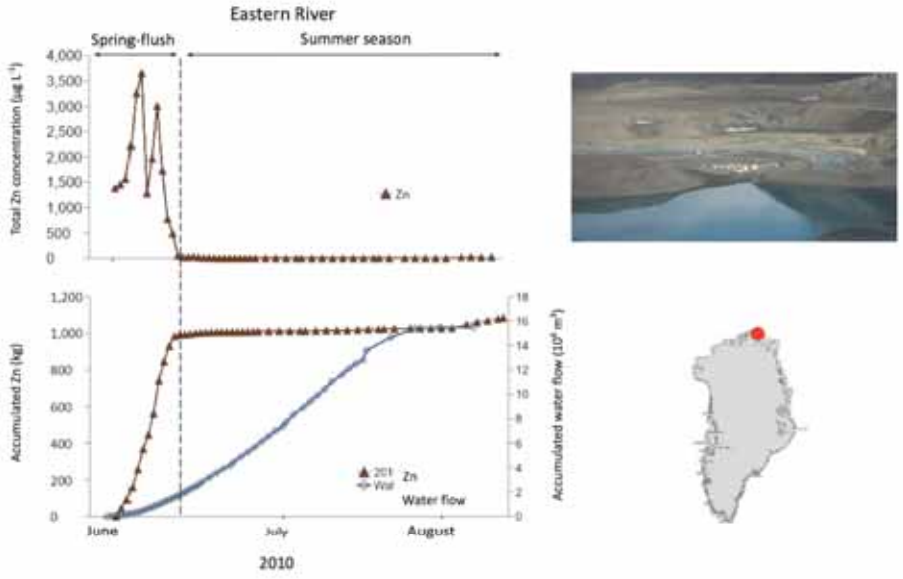
2 PAG: Potentially Acid Generating rock (PAG) is rock with pyrite that when oxidized by surface weathering may form acid which can then leach metals.

2 AMD: Acid mine drainage (AMD) is drainage/waste water with reduced pH and high levels of dissolved metals.

Acid rock drainage (ARD)
Contaminated neutral drainage (CND).



Arctic Conditions with PAG issue
Baseline studies and why it is important (Citronen Fjord)



Søndergaard et al. 2012. Cold Reg Sci Technol 71, 90-94

Example: Raglan Mine – Quebec
Research-based PAG management published 2017

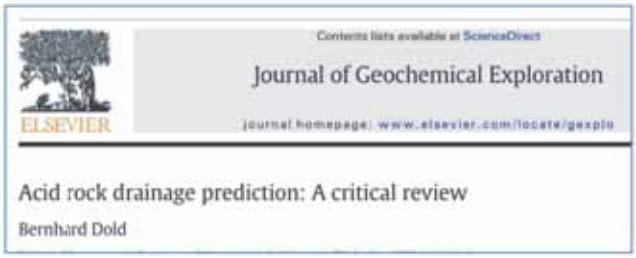
AMD: Acid mine drainage
Sulphide nickel deposits in Nunavik,
The mine began production in 1997

Raglan Mine tailings are composed of fine-grained particles with high sulphide content, mainly in the form of pyrrhotite. **The tailings were classified as potentially acid-generating** using acid-base accounting.

Desulphurization using a froth flotation process allowed for the removal of more than >95% of the pyrrhotite occurring within the Raglan Mine tailings.
In terms of environmental behavior, the remaining pyrrhotite in the desulphurized tailings was considered to be non-reactive due to their association with gangue minerals (mainly lizardite).

These tailings did not present significant risk of acid generation and **the leached metals (particularly Ni) are in agreement with the criteria set by Directive 019.**

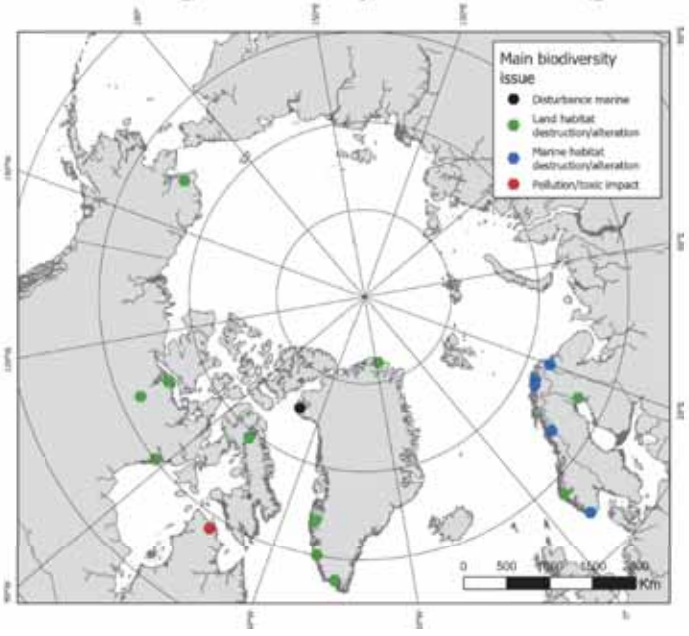
Geochemical testing: has to be early and integrated



In many modern mining operations, quantitative mineral data is nowadays produced in order to enhance the recovery of the extraction process by **the incorporation of geometallurgical information the use of this very same existing data for Acid Rock Drainage (ARD) prediction** can increase importantly the precision of ARD prediction, often without additional costs and testing. The only requirement is the **interdisciplinary collaboration** between the different divisions and data ex-change in a modern mining operation.

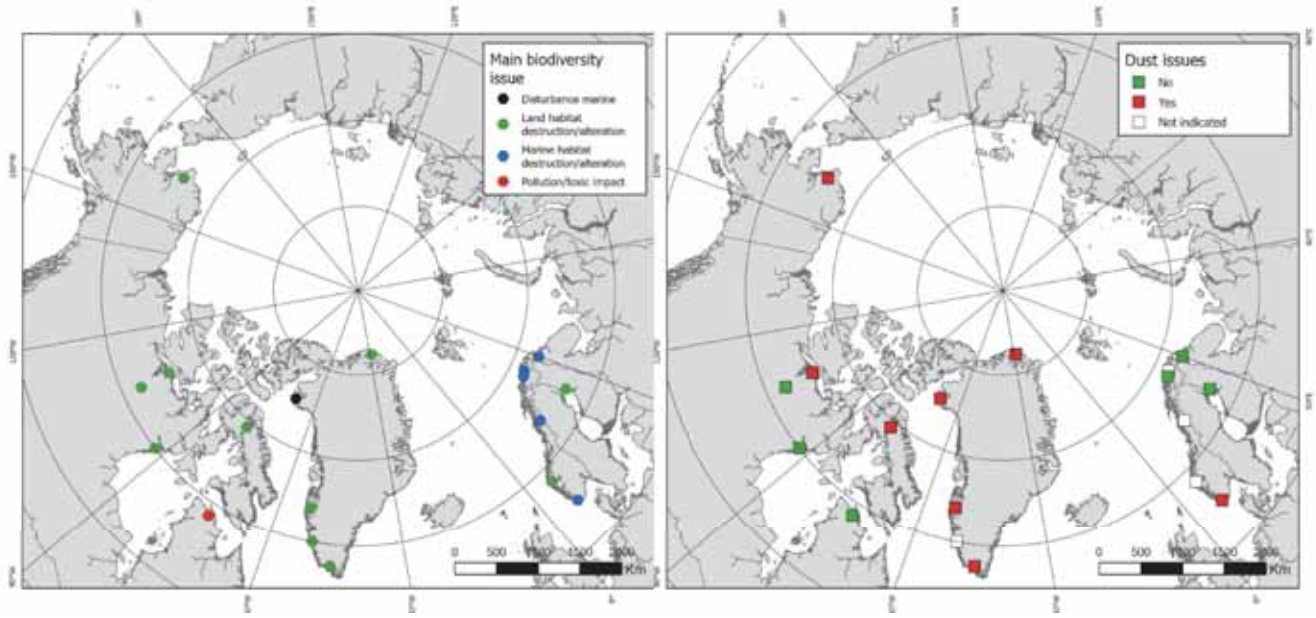
B. Dold 2017. Acid rock drainage prediction: A critical review
J. Geochem. Explor., 172 (2017), pp. 120-132

Assessing the footprint – during and after the operation

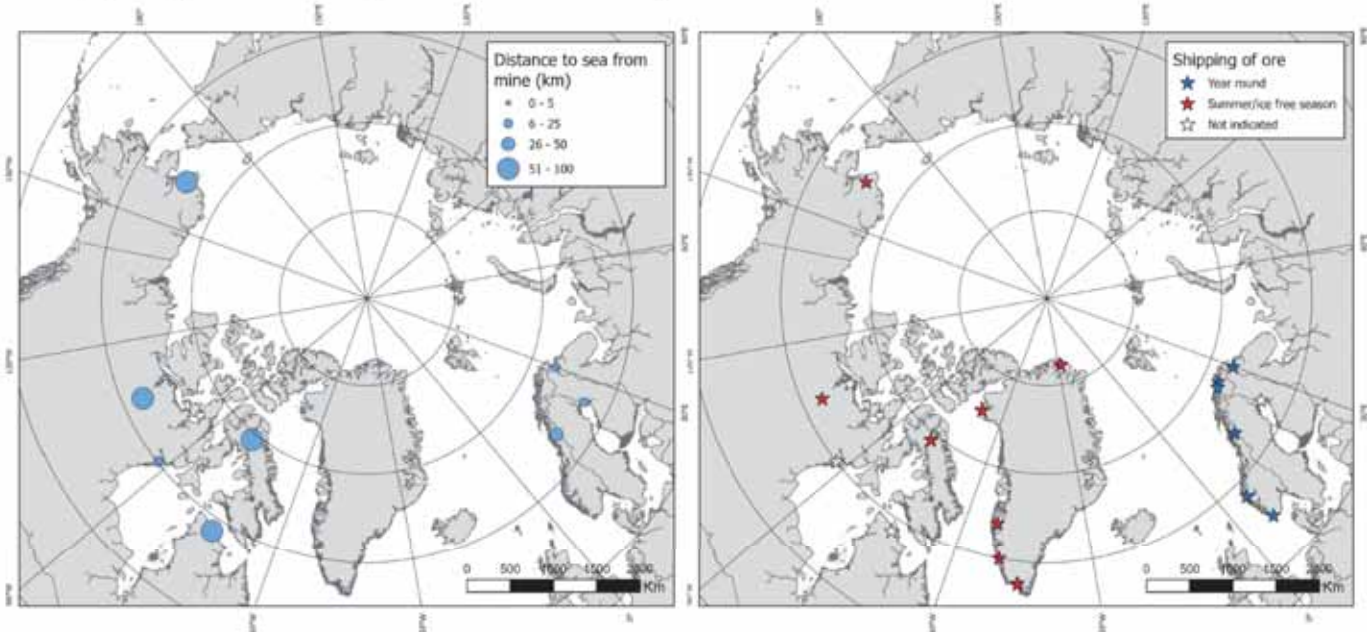


Diverse issues

Assessing the footprint – during and after the operation - Dust



Shipping of ore - a part of the footprint



Shipping of ore - Baffin Bay - and the importance of monitoring

PAME 2022

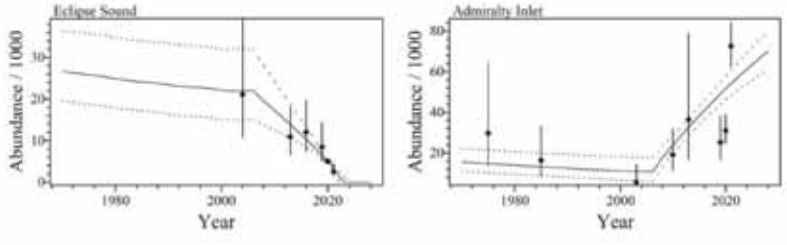
MARY RIVER Iron Mine

A total of 188 one-way transits of project-related ships occurred during July-October 2020, with icebreakers used early and late in the season.

Aerial surveys for marine mammals have been conducted since 2006.

The monitoring showed severe decline in the Narwhal summering population in Eclipse bay

The importance of regional monitoring - Displacement of Narwhals



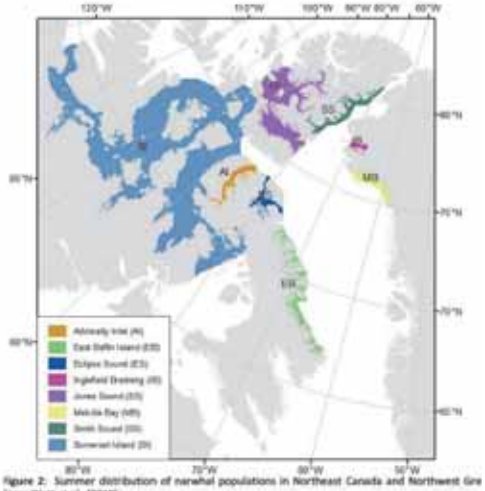
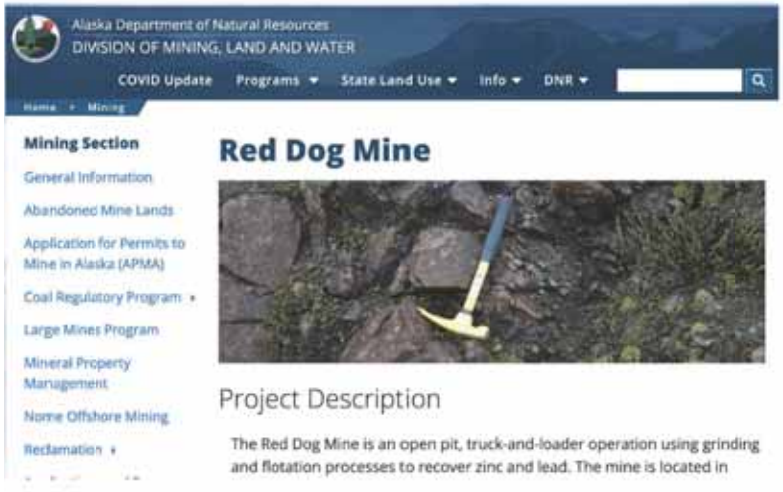


Figure 2: Summer distribution of narwhal populations in Northeast Canada and Northwest Gre from Watt et al. (2019)

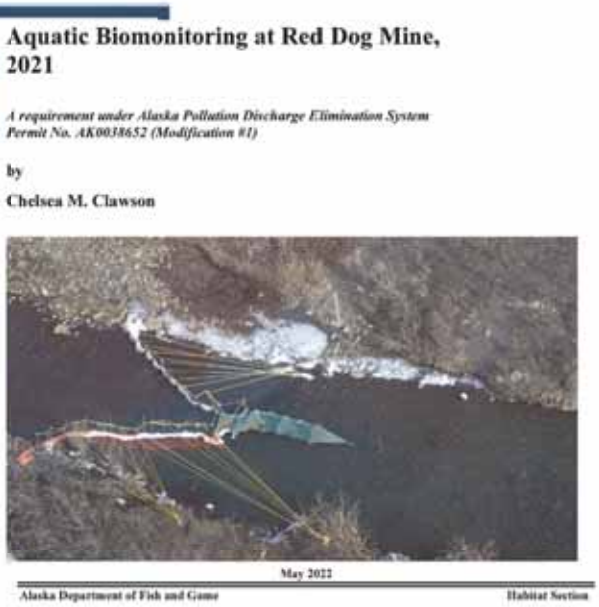
JOINT DISTURBANCE WORKSHOP OF THE NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP ON THE POPULATION STATUS OF NARWHAL AND BELUGA IN THE NORTH ATLANTIC. 2022.

Monitoring and Transparency
is evolving

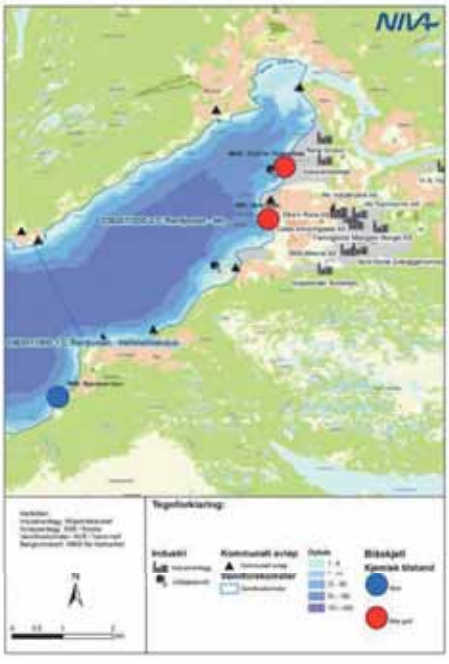
Monitoring and Transparency
an Alaskan example



Monitoring and Transparency
an Alaskan example



Monitoring and Transparency
a Norway example



Lessons learned

- Background studies, *reflecting year-round conditions, early planning*
  - geochemical leaching tests (and use metallurgical information) and research approach
  - biodiversity, local and regional/population occurrence and sensitivities, integration

- Monitoring, *surprises do occur*
  - monitoring, regional info needed, take account of climate change, feed-back loop
  - new opportunities with technical devices
  - local involvement

- Increasing transparency, *building trust*
  - e.g. online reporting of monitoring results

- Preparing for Ecosystem Based Management in a changing Arctic ?
  - future management across sectors and involving stakeholders, managing cumulative impacts,
  -shifting baselines - research based solutions

Arctic mining - Presentation on EU Best Available Techniques Reference Document for the Management of Waste from Extractive Industries: Key principles and examples of BAT conclusions

Speaker: Soile Nieminen, Centre for Economic Development, Transport and the Environment, Finland

Biography: *Soile Nieminen is a Chief Environmental Specialist in environmental safety of mining. She represents the Centre for Economic Development, Transport and the Environment, Finland.*

What is the Purpose of your Talk?

The presentation gives a general overview on the European Commission Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries (MWEI BREF) published in December 2018. The purpose of the talk is to highlight the key principles and approaches of the BAT conclusions as well as to present examples of some important BATs for arctic mining. Also, other recently published European guidance on environmental management of the extractive sector is presented.

Abstract:

Mining generates a high amount of extractive waste that requires appropriate management. Inappropriate design and operation of extractive waste management may cause major accidents and have catastrophic impacts.

MWEI BREF is a technical document representing the results of the European exchange of information on the BAT for the management of extractive waste and associated monitoring. It provides information of identified generic and risk-specific BAT to prevent and reduce as far as possible any adverse effects on the environment and human health from the management of extractive waste.

The goal of the MWEI BREF is to ensure the short-term and long-term safe and environmentally responsible deposition of extractive waste. Generic BATs are generally applicable in every site where extractive waste is managed, while risk-specific BATs are applicable to sites where specific environmental risks and possible impacts are identified. Risk assessment is an overarching principle in MWEI BREF BAT conclusions. A risk-specific approach applied in the document enables it to reflect the vast diversity in the extractive waste activities, extractive sectors, and geographical, climatic, and site-specific conditions in Europe. The approach is based on risk assessment and management principles to identify, evaluate, and manage the potential impacts of an extractive waste facility along the whole life cycle. The Environmental Risk and Impact Evaluation is a core BAT in the BREF and requires site-specific assessment of the suitability and application of the risk-specific BATs.

A second key principle of the MWEI BREF is the design for closure approach. To achieve environmentally responsible management of extractive waste, its deposition is planned

and designed for closure from the very beginning and the closure is continuously adapted and improved.

The third key principle of the MWEI BREF is the integrated design approach in the extractive waste management. According to the approach all relevant parameters are considered in designing the construction of the EWFs to optimize the overall environmental, human health and safety aspects in the short and long term.

Recently the European Commission has also published several best practices guides on the extractive sector (e.g., on extractive waste management plans, mine closure and financial guarantees and environmental impact assessment). Also, a guidance on risk management of the extractive sector is being developed. In addition to MWEI BREF these documents are important European guidance to support sustainable mining and environmentally safe extractive waste management.

https://ec.europa.eu › pdf › waste › mining

Link to *Presentation*

Elinkeino-, liikenne- ja ympäristökeskus

Arctic Mining – Presentation on EU Best Available Techniques Reference Document for the Management of Waste from Extractive Industries: *Key principles and examples of BAT conclusions*

Soile Nieminen

21.3.2023

Arctic Mining Workshop 21 - 23 March 2023
Environmental issues, mitigation and pollution control for marine and coastal mining

Background

- Mining generates high amount of extractive waste that requires appropriate management
- In appropriate design and operation of extractive waste management may cause major accidents and have catastrophic impacts
- According to Extractive Waste Directive (2006/21/EC)
  - Member States shall ensure that operators responsible for the management of extractive waste **take all measures necessary to prevent or reduce as far as possible any adverse effects on the environment and human health** brought about as a result of the management of extractive waste. These measures shall be based, inter alia, on the **best available techniques** without prescribing the use of any technique or specific technology, but taking into account the technical characteristics of the waste facility, its geographical location and the local environmental conditions.
  - Member States shall take the necessary measures to ensure that competent authorities periodically reconsider and, where necessary, update permit conditions in light of the information exchange on substantial changes in best available techniques.
  - **Best available techniques** are the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for **providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole**.

Elinkeino-, liikenne- ja ympäristökeskus

The Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries (MWEI BREF)

- The MWEI BREF document was published in December 2018
  - Available in: http://publications.jrc.ec.europa.eu/repository/handle/JRC109657
  - It is a technical document representing the results of the exchange of information, organised by the European Commission, on BAT for the management of extractive waste and associated monitoring
- The MWEI BREF has been drawn up within the framework of the Extractive Waste Directive (EWD, 2006/21/EC), which is different from the Industrial Emission Directive (IED, 2010/75/EU) framework under which most BREFs by the European Commission are developed or reviewed

Application of MWEI BREF and BAT conclusions

- The MWEI BREF provides up-to-date information and data on the management of extractive waste
- It supports decision makers by providing a **list of identified BAT to prevent or reduce as far as possible any adverse effects on the environment and human health** brought about as a result of the management of extractive waste
  - Techniques listed and described in the MWEI BREF BAT conclusions are neither prescriptive nor exhaustive
  - Also, other techniques may be used that ensure at least an equivalent level of environmental protection
- The goal of the MWEI BREF is to **ensure the short-term and long-term safe and environmentally responsible deposition of extractive waste**
  - Taking into account the **technical characteristics of the waste facility, its geographical location and the local environmental conditions**
- MWEI BREF does not contain sector-specific BAT associated emission levels (BAT-AEL)
  - Provides site specific information on environmental performance levels and the conditions under which these levels were achieved
  - Limited data on emission levels and difficulty to derive sector-specific environmental performance levels or associated emission levels → no legally binding BAT-AEL

Ilmasto-, ilkenne- ja ympäristökeskus

Processes and activities covered by the BAT Conclusions

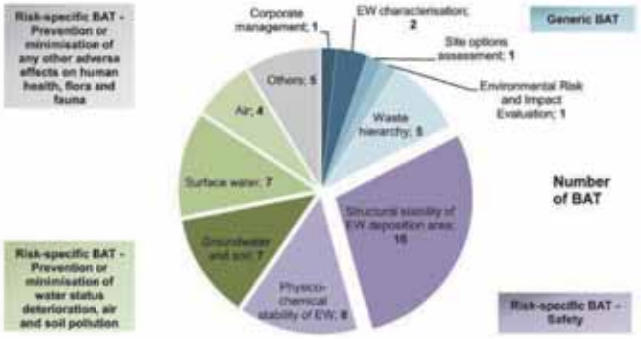
- **Management of extractive waste from <u>onshore extractive activities</u>**
- Handling/transport of extractive waste (e.g. loading, unloading and on-site transport)
- Treatment of extractive waste
- Deposition of extractive waste
- Activities directly associated with the management of extractive waste
  - Treatment of Extractive Waste Influenced Water (EWIW);
  - Preparing extractive waste to be placed back into excavation voids
- **Sea tailings disposal (STD) were not included in BAT conclusions**

BAT conclusions and risk-specific approach

- **A risk-specific approach** is applied in the document
  - Risk assessment overarching principle in MWEI BREF BAT conclusions
  - Enables to reflect the vast diversity in the extractive waste activities, extractive sectors, sectors and geographical, climatic and site-specific conditions in Europe
  - Understanding of the risks provides basis for achieving the most appropriate approach to be used to treat the risk
  - Based on risk assessment and management principles to identify, evaluate, and manage the potential impacts of an extractive waste facilities along the whole life cycle
- **An integrated approach** is required for the implementation of BAT
  - A number of important BAT conclusions are interlinked
  - Links between the BAT are introduced by cross-references
  - The applicability and relevance of some BAT conclusions depends on the result of others

BAT conclusions - Generic and Risk-specific BAT

- BAT conclusions are divided into Generic and Risk-specific BAT
  - **Generic BAT** are generally applicable in every site where extractive waste is managed
  - **Risk-specific BAT** are applicable to sites where specific environmental risks and possible impacts are identified
- BAT conclusions include specifics for application of the BAT during the different life cycle phases
- Evaluation of the site-specific applicability of the risk-specific BAT based on environmental risk and impact assessment



Garbarino et al. 2020. Available: https://doi.org/10.1016/j.resourpol.2020.101782

Environmental Risk and Impact Evaluation (BAT 5) - the core BAT

- **Key part of the life cycle management** of extractive waste management site
  - Environmental risks and impacts are identified, analysed and evaluated over the whole life cycle
- Considers the full spectrum of hazards and risk elements, including source-pathway-receptor linkages
- Environmental risk and impact evaluation is based on e.g.
  - Initial characterisation of extractive waste
  - Extractive waste site options
  - Extractive waste management options (e.g. handling/transport, treatment and deposition alternatives)
    - Adapted to the site-specific conditions
- Applicability of the different risk-specific BAT is assessed on the base of the results of a proper of Environmental Risk and Impact Evaluation
  - Site-specific assessment of the suitability and application of the risk-specific BATs
  - Deployment of BAT is adapted according to an evaluation of the environmental risks and possible impacts
  - Updated over time to reflect changes in the operation or closure and after-closure based on monitoring findings

Design for closure approach (BAT 11) (1/2)

- **To achieve environmentally responsible management of extractive waste its deposition is planned and designed for closure from the very beginning**
  - Potential impacts on the environment and human health can be reduced substantially by **considering the whole life cycle of the EWFs** from the very beginning
    - Identification of the closure strategy
    - Quantification of the long-term environmental behavior and structural stability of the deposition area
  - Focus on **progressive rehabilitation** whenever possible
    - Design that takes into consideration of premature closure
  - Assessment of costs related to the proposed and alternative closure strategies (e.g. a cost benefit analysis)
    - Details on the final landform and surface rehabilitation, long-term stability analyses and monitoring

Design for closure approach (BAT 11) (2/2)

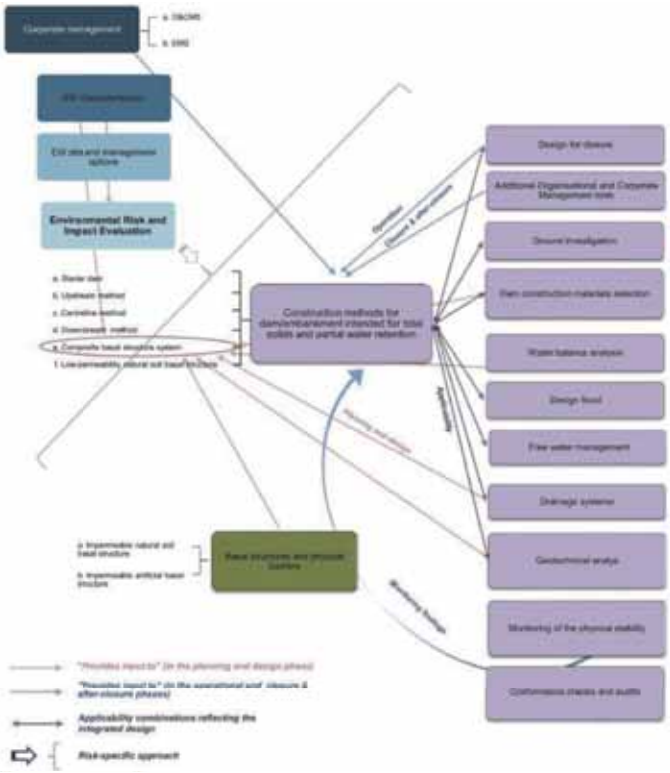
- The management of extractive waste deposition areas and **closure plans continuously adapted and improved**
  - Initial closure and after-closure plan already in the planning and design phase
  - During the operational phase closure and after-closure plans are reviewed
    - Update of the closure design assumptions
  - Final closure plan reviewed and updated in the closure phase
- **Integration of the EWF closure and after-closure planning into the periodic extraction plans**

Integrated design approach (1/2)

- A design that takes into account **all the relevant parameters in order to optimize the overall environmental, human health and safety aspects in the short and long-term**
  - Selection of the dam construction method construction method is based on the results of a proper Environmental Risk and Impact Evaluation
  - BAT is to design the dam using modern engineering principles to ensure that the embankments are adequately drained, that an appropriate beach length is guaranteed at all times and that the phreatic surface is controlled
  - **The dam** is monitored and maintained during the operational phase and the closure and after-closure phase, while applying corporate management systems and a design for closure approach
  - BAT is also to include **a basal structure**, whose structure and permeability are related to the nature of the extractive waste to be contained
- **To ensure long term structural stability of the EWF and long-term chemical and physical stability of the extractive waste**

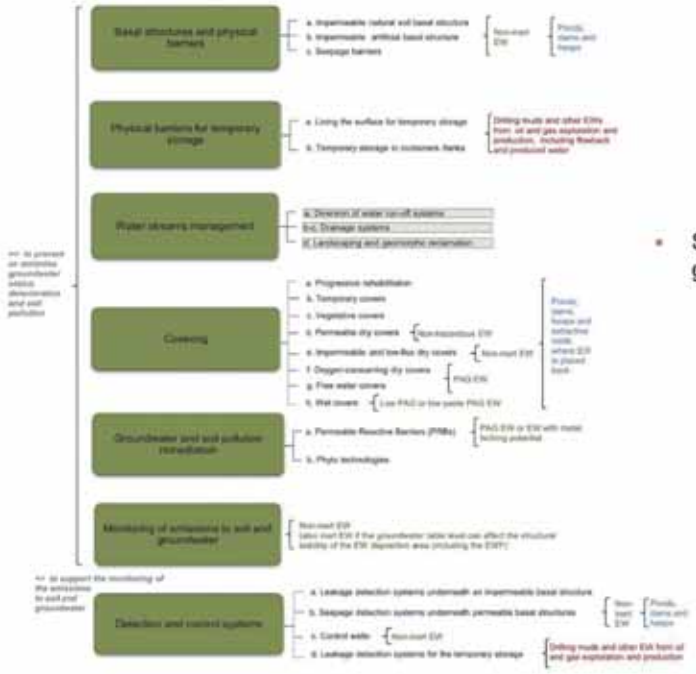
Integrated design approach (2/2)

- The integrated design approach consists of the following:
  - **Selecting the dam construction method by considering all the relevant parameters from the design for closure**, e.g.
    - Ground investigation
    - Dam construction materials selection
    - Design flood evaluation
    - Free water management
    - Drainage systems
    - Geotechnical analyses
  - **Designing a (composite) basal structure (an impermeable basal structure) in combination with a proper drainage system** based on e.g.
    - Hydraulic conductivity of the basal structure
    - Extractive waste characteristics
    - Water balance
    - On the design criteria resulting from the dam construction material selection and the geotechnical analysis
- Similar principles and approaches apply for the BAT on construction methods for heaps



- Example of different BAT related to integrated design for dam/embankment for total solids and partial water retention

Garbarino et al. 2020. Available: https://doi.org/10.1016/j.resourpol.2020.101782



- Scheme of risk-spesific BAT to prevent or minimise groundwater status deterioration and soil pollution

Garbarino et al. 2020. Available: https://doi.org/10.1016/j.resourpol.2020.101782

BAT in management and treatment of extractive waste impacted water

- In MWEI BREF specific focus is given to the management and treatment of EWIW
- Proper management of water is crucial to help ensuring the structural stability of the EWF and the physical stability of the waste
- **Management of water is based on applying following BAT:**
  - ✔ Re-use or recycling of excess water
  - ✔ Diversion of water run-off during operation
  - ✔ Landscaping and geomorphic reclamation (aim at preventing or minimising the EWIW generation)
  - ✔ Water balance analysis
  - ✔ Water management plan
  - ✔ Free water management
  - ✔ Drainage systems
  - ✔ Geotechnical analysis
  - ✔ Monitoring
  - ✔ Solid/liquid control and compaction
  - ✔ Consolidation and deposition of extractive waste
  - ✔ Emissions to surface water are minimised by applying following BAT:
  - ✔ Removal of suspended solids
  - ✔ Removal of suspended liquid particles
  - ✔ Removal of dissolved substances
  - ✔ Neutralization of EWIW prior to discharge by active or passive treatments
  - ✔ Monitoring

Recent European Commission guidance on best practices of extractive sector

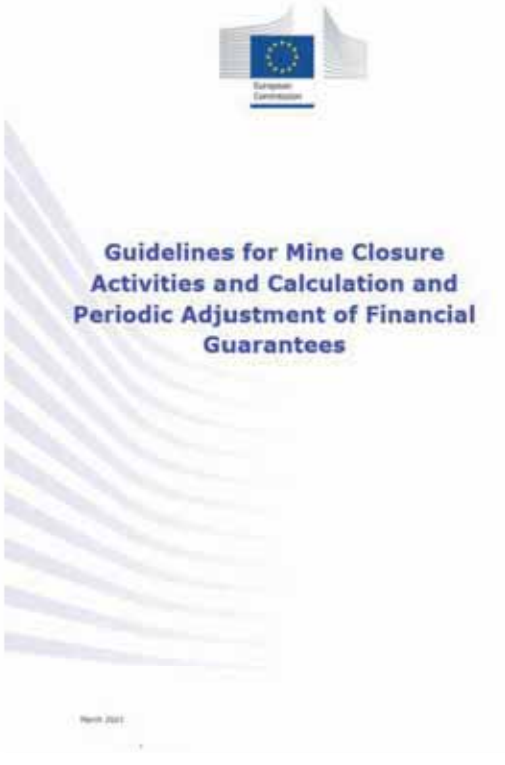
- ***Study supporting the elaboration of guidance on best practices in the extractive waste management plans***
- ***A review of European Union legal provisions on the environmental impact assessment of non-energy minerals extraction projects***
- ***Guidelines for mine closure activities and calculation and periodic adjustment of financial guarantees***
- ***Study supporting the development of general guidance on the implementation of the Extractive Waste Directive***
- ***Collection of available techniques for the prevention or reduction of environmental impacts in non-energy extractive industries (NEEI)***
- Also, ***guidelines for best risk management approaches in the extractive sector*** are being developed
- In addition to MWEI BREF, these documents are important European guidance to support sustainable mining and environmentally safe extractive waste management

Guidance on best practices in the EWMPs

- Study supporting the elaboration of guidance on best practices in the Extractive Waste Management Plans
- For waste facilities that require a permit, the **EWMP is part of the permit application**
- The publication describes **guidelines for best practices and methodology to develop EWMPs**
- The focus is on (a) the prevention or reduction of extractive waste generation and of its harmfulness, (b) the recovery of extractive waste (by recycling, re-use or reclaiming), as well as (c) the assurance of short- and long-term safe disposal of extractive waste
- The key principle of guide is the utilization of an **iterative, risk-based assessment** in the preparation of the waste management plan
  - This means identifying risks during the whole life cycle of the extractive operation, assessing risks and impacts, and planning actions to prevent and reduce risks and impacts as part of the preparation of the waste management plan
- The publication consist of two parts, which were developed based on risk assessment principles:
  - The first part focuses on the **circular economy during the life cycle of an extractive project** and the promotion of the utilization of extractive waste
  - The second part focuses on **ensuring the environmental safety of extractive waste at each stage of the life-cycle of an extractive waste facility**

Guidance on mine closure plans

- Guidelines for Mine Closure Activities and Calculation and Periodic Adjustment of Financial Guarantees
- **The EWMP must include a closure plan**, including site rehabilitation, after-closure procedures and monitoring
  - Often a separate closure plan
  - **Parallel, periodic review** of the plans
- Contains guidance for:
  - Collection and description of the **Closure Best Practices** by Mining Typology
  - **FG calculation** prior to the commencement of waste deposit, and FG **periodic adjustment**
  - **Content of the closure plan**
  - **Elaboration of updated closure plans** taking into account the environmental impact of the operations
  - **Approaches for determining the cost** of the respective activities to implement the closure plan



Elinkeino-, liikenne- ja ympäristökeskus

Thank you for your attention!

For more information please contact:
soile.nieminen@ely-keskus.fi

Session 2A) Pollution Mitigation and Maintaining Biodiversity

Marine tailing disposal: The Norwegian experience
Speaker: Hilde Cecilie Trannum, NIVA
Biography: *Senior Research Scientist (PhD) at Norwegian Institute for Water Research NIVA) and Associate Professor at University of Agder*
What is the Purpose of your Talk? The aim of the talk is to provide insights and lessons learnt from Norwegian sea deposits regarding environmental impacts, and to give an overview of major knowledge gaps, as well as presenting guidelines for the development of best available techniques for submarine tailing disposals.
Abstract: Submarine tailing disposal (STD) in fjords from land-based mines has been a practice in Norway, although controversial. Until quite recently, the impacts on marine ecosystems had received relatively little scientific attention. To increase such knowledge, a multidisciplinary research programme (NYKOS; New Knowledge on Sea Deposits) was initiated. The major results from this programme, as well as other research studies and environmental monitoring programmes will be presented; spanning from geological seabed mapping to toxicity testing and experiments on the benthic community level, and from fjords from the south to the north of Norway. Experience from the Arctic fjord, Repparfjorden, will receive extra emphasis, representing both an old deposition area (> 40 y) and a pre-mining site. By combining a field and an experimental approach, both short- and long-term benthic recovery was studied in this fjord. Major knowledge gaps arising from the existing knowledge will be presented, as well as suggestions for guidelines for the development of best available techniques for submarine tailing disposals, based on the Norwegian experience.
Link to *Presentation*

PAME-workshop 2023

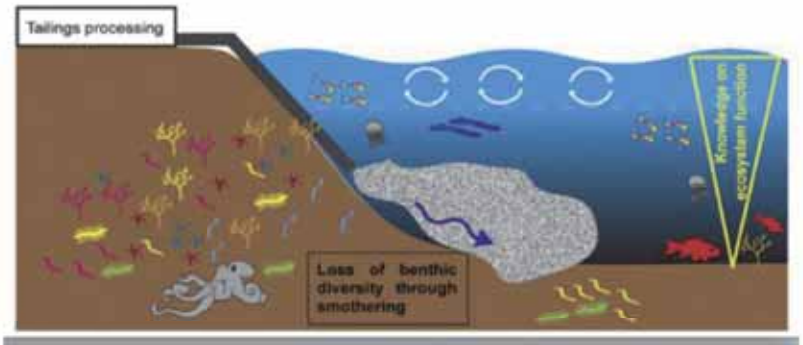
Marine Tailing Disposal: The Norwegian Experience

Hilde Cecilie Trannum
Senior researcher, Norwegian Institute for Water Research
Associate professor, University of Agder

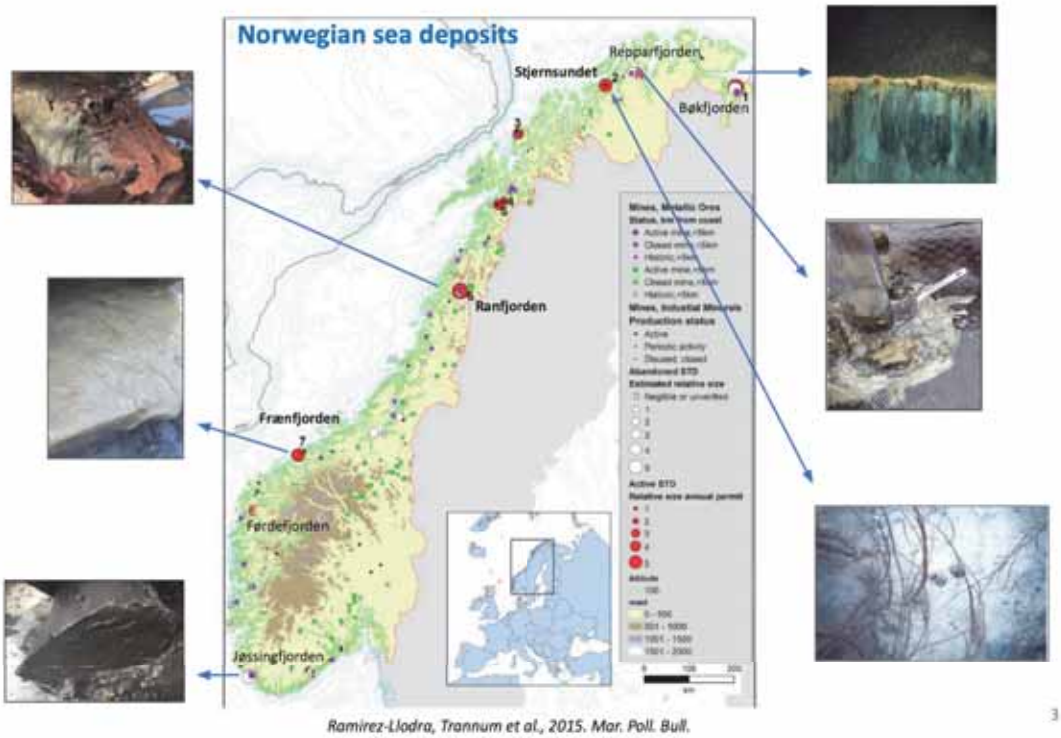
Norsk institutt for vannforskning

Submarine tailings disposal (STD)

- Disposal of tailings in the sea
- In Norway, fjords are often selected as disposal sites because
  - Many mineral ores are located adjacent to the coast
  - Natural sedimentation basins
- Magnitude up to order of million tons/year!
- Mine tailings
  - Particles of chrushed stone
  - Minerals and metals
  - Process chemicals



Ramirez-Llodra, Trannum et al., 2015.



Ramirez-Llodra, Trannum et al., 2015. Mar. Poll. Bull.

3

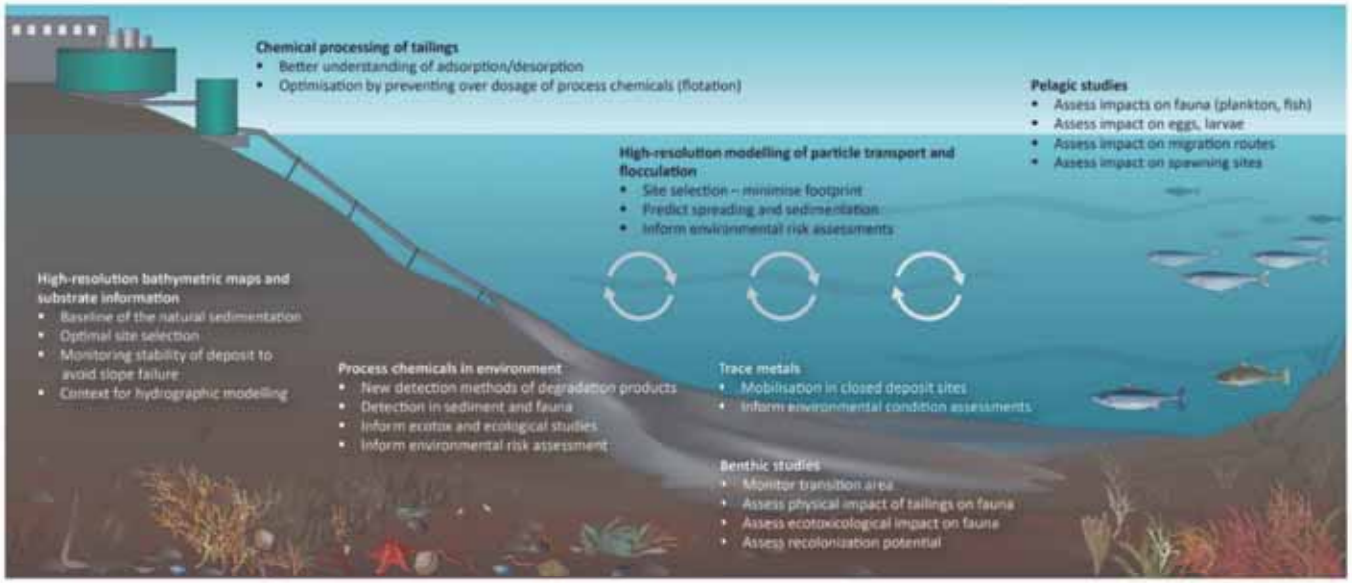
Controversial!

Fjorden forever

- De skal ikke få drepe fjorden vår. Ikke faen

4

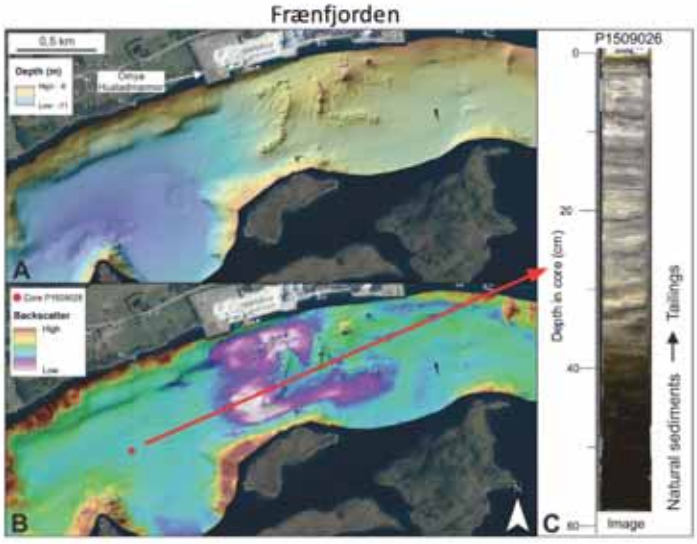
Study framework of the research project NYKOS



Ramirez-Llodra, Trannum et al., 2022. Mar. Poll. Bull.

Geological mapping and monitoring of the seafloor

- The fjord bathymetry will be permanently altered!
- The dispersal, distribution and stability of submarine tailings are linked to the natural processes operating on the seafloor
- Modern multibeam echosounder technology can provide high-resolution bathymetry and backscatter datasets, which, combined with the results of seafloor sediment characterization (seabed samples) and visual observations (video footages of seafloor) can be used to produce detailed, full spatial coverage geological maps
- Such maps provide information on sediment dynamics and can outline areas where erosion or accumulation processes from STDs are prevailing. The maps also help to uncover areas that can be sensitive to slope failures

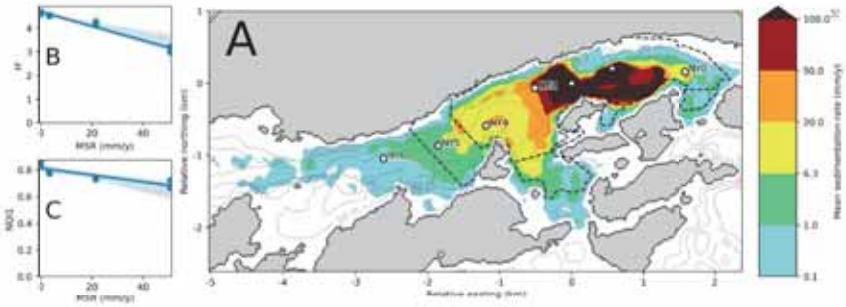


Baeten et al., 2020, Nor. J. Geol.

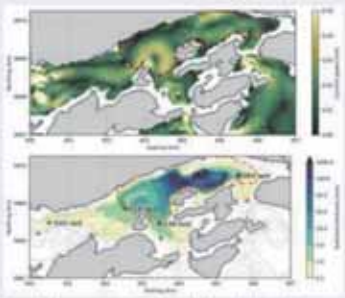
Modelling and measuring spreading of tailings particles

- A new particle imaging system to directly observe mine tailings flocs in the ocean was developed
- Numerical models that can simulate the spreading and flocculation of tailings particles were developed

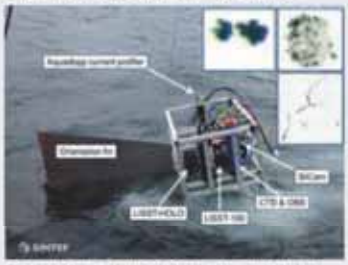
- Model simulations combined with knowledge on biological impacts of tailings can be used to determine environmental risk
- Model simulations can be used to minimize environmental footprint through optimization of the discharge



Nepstad et al., 2020, Reg. Stud. Mar. Sci.
Ramirez-Llodra et al., 2022, Mar. Poll. Bull



Results from numerical model simulations. Top: ocean currents in Frænfjorden showing eddy structures at 20 m depth (month average). Bottom: sedimentation rates from a tailings scharge.



Floc imaging and supporting instruments being deployed in Frænfjorden.

Dynamics of process chemicals pre and post discharge

- In the processing plant: State and mobility of chemicals in tailings mixed with sea water prior to discharge was studied
- In the environment: Transformation products of chemicals were studied, by a novel analytical procedure

- Transformation product of a flotation chemical was detected in sediments, pore water and benthic fauna (holothurians) and blue mussels up to 2 km from the discharge outlet
- A suite of biomarkers measured in the mussels indicated a clear stress response

- The methodology developed revealed a large potential to develop advanced monitoring strategies and to understand how process chemicals in mine tailings migrate and transform in the environment.

Ibragimova and Kleiv, 2018
Brooks et al., 2018, Mar. Environ. Res.

Deployment of mussels in a fjord recipient to study environmentally relevant impacts of the tailings to mussel health and chemical bioaccumulation.

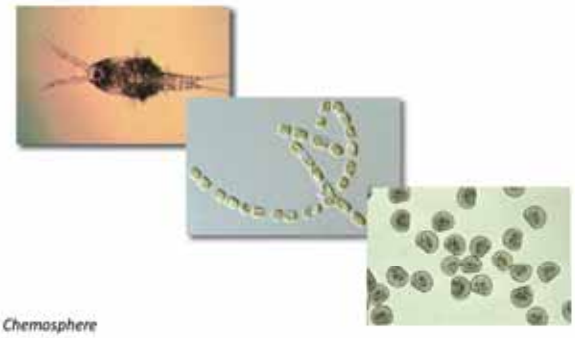
Sediment samples from Frænfjorden (left) where taken using a Gemini corer (right).
Photo: E. Ramirez-Llodra (NIVA).

Sea cucumbers sampled in Frænfjorden being prepared for analysis of process chemicals.
Photo: C. Escudero (NIVA).

Ecotoxicology

- Ecotoxicity assessments (algae, Crustacea, and Mollusca) with different tailings
  - Sibelco (no chemicals)
  - Sydvaranger (flocculation chemicals)
  - Omya Hustadmarmor (flotation chemicals, very fine sediment)

- Differences in particle and waterborne toxicity between the mine tailings
  - Sibelco tailings were most toxic based on waterborne exposures
  - Hustadmarmor tailings were most toxicity based on sediment exposures



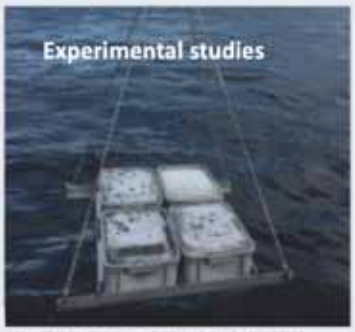
Brooks et al., 2019, Chemosphere

Effects on benthic fauna

- Responses were studied at the benthic community level (structure & function) with the three different tailings
- The experimental studies showed:
  - Significant effect of all tailings > 2 cm
  - Most pronounced effects of fine-grained tailings with flotation chemicals (Hustadmarmor)
  - Rapid initial colonization
- The field studies showed:
  - The infauna close to the tailings outflow was dominated by tolerant species, indicating a community shift
  - The abundance of epifauna showed a stronger reduction close to the tailing outflow than the infauna

***In situ* (Frænfjorden - Hustadmarmor)**

Trannum et al., 2018; 2019; 2020



Recolonization experiment where sediments capped with thin layers of tailings are subject to colonization of benthic fauna. Photo H.C. Trannum

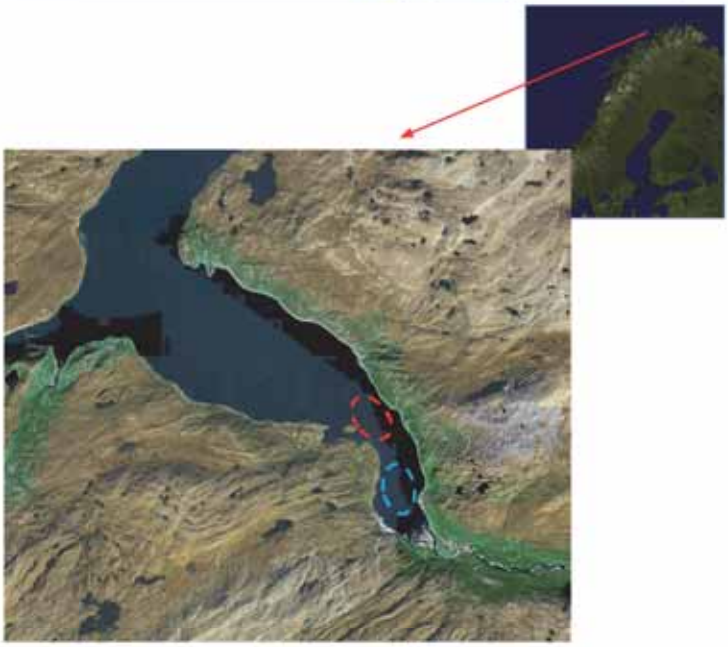
Mesocosm experiment where benthic fauna is exposed to mine tailings. Photo H.C. Trannum

Repparfjorden (Nussir)

Old (and new) sea deposits
Sulfide tailings

Jøssingfjorden (Titania)

Repparfjorden – past and present



Disposal of mine tailings

1972-1978: Disposal of approx. 1 million ton of copper-mine tailings

2019: Permit for new disposal
Operating period ~30 years
1-2 million ton mine tailings pr year

Jøssingfjorden – past and present

Disposal of mine tailings

1960 - 1994: Sea disposal

1994 - present: Land deposit

Future disposal where?

Mesocosm experiment: Nussir and Titania tailings

Method: Mesocosm – multispecies test

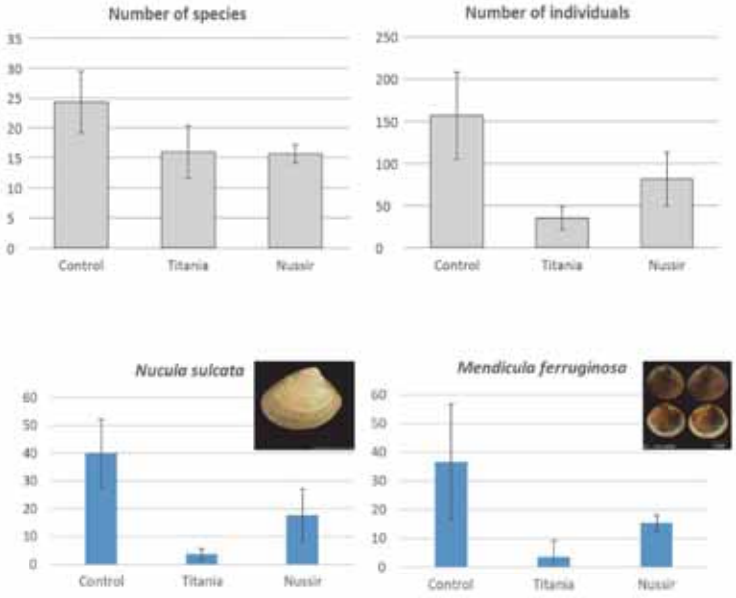
Treatments:

- Control
- Titania tailings (2 cm)
- Nussir tailings (2 cm)

Duration: 4.5 months

Samples: Macrofauna, sediment parameters, trace metal concentrations

Mesocosm: Mine tailings affected sediment communities



Main findings:

- Mortality in both tailings treatments
- High metal levels in tailings treatments

Trannum & Schaanning, 2017;
Schaanning & Trannum in prep.

Repparfjorden colonisation experiment

Location: Repparfjorden – close to new deposit site

Method: Experimental trays, Repparfjorden tailings

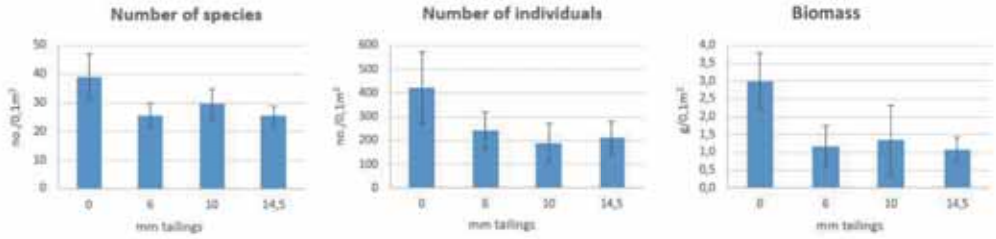
Treatments:

- Control
- 6 mm tailings
- 10 mm tailings
- 14.5 mm tailings

Duration: 15 months

Samples: Macrofauna, sediment parameters, trace metal concentrations

Mine tailings negatively affected colonization of marine species



Main findings:

- Rapid initial colonization
- Reduced colonization at a scale of mm
- Changed substrate and/or toxic effect?

Trannum et al., 2023, J. Sea Res.

The seafloor is still affected by the old deposits

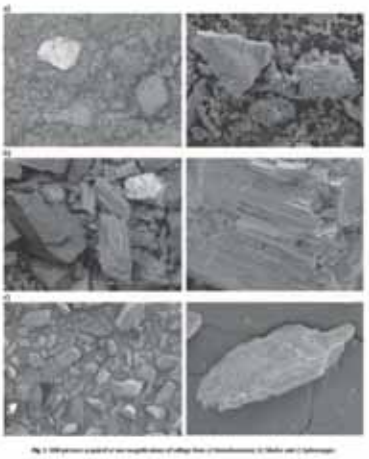
Main findings:

- Tailings from the old deposit are still present and enriched in metals
- The fauna obtains class «good», according to the WFD, altough there are signs of stress
- Full community recovery and normalisation of metal leakage rates may take several decades, despite an initial rapid colonization
- Capping may prevent long-lasting effects

Schaanning, Trannum et al., 2019, Mar. Poll. Bull
Trannum et al., 2023, J. Sea Res.

Impact mechanisms of mine tailings

- Common for all mine tailings:
  - Hypersedimentation (-> food dilution)
  - Allochtonous material in the marine environment
  - Chrushing and grinding increase the surface area and the reaction rates
- Depending on the ore and process plant:
  - Size (often very small)
  - Shape (freshly grinded, sharp edges, needles)
  - Reactive minerals (e.g. sulphides)
  - Remnants of process chemicals (flotation & flocculation)
- Fine-grained tailings with flotation chemicals were most harmful



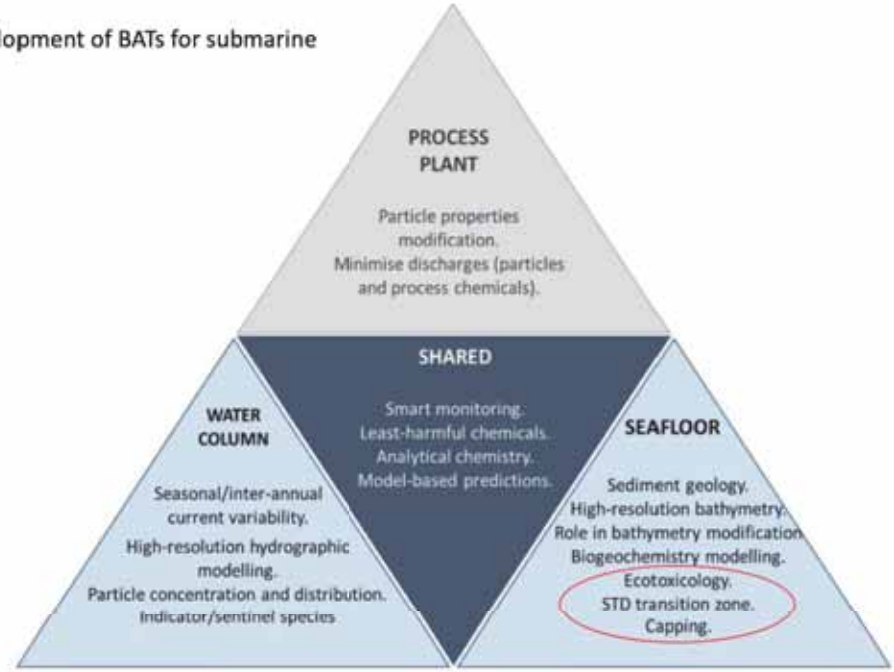
Trannum et al., 2018. Sci. Tot. Env.

"Biological" knowledge gaps

- Better understanding of
  - effects on the pelagic community
  - effects on hard substrate/sessile fauna
  - the particular impact mechanisms and effects of particle shape and size in particular
  - the potential for accumulation and trophic transfer of tailings-associated contaminants (metals and chemicals) in biota
- Development of ecological indicators and thresholds to identify serious harm
- Cumulative impacts with other stressors (climate change, other industry, …)

Development of BATs

Key areas proposed for the development of BATs for submarine tailing disposal operations.



Ramirez-Llodra, Trannum et al., 2022. Mar. Poll. Bull.

FURTHER READING


THANK YOU FOR YOUR ATTENTION!
NYKOS
Norsk institutt for vannforskning
Akvaplan niva

Industry process chemicals and discharge of wastewater to the Arctic environment

Speaker: Kim Gustavson, Senior Scientist, Aarhus University

Biography: *Kim Gustavson has more than 25 years of experience with project management, research and consultancy assignments for private companies and environment authorities. He has key expertise within fate and effect of metal, oil components, pesticides, persistent organic pollutants in aquatic and terrestrial ecosystems, biological and chemical monitoring.*

Abstract / What is the Purpose of your Talk?

Environmental concerns related to use of chemicals in mining projects during processing and enrichment of metals or minerals are to ensure these are degradable, not toxic or can not be bioaccumulated.

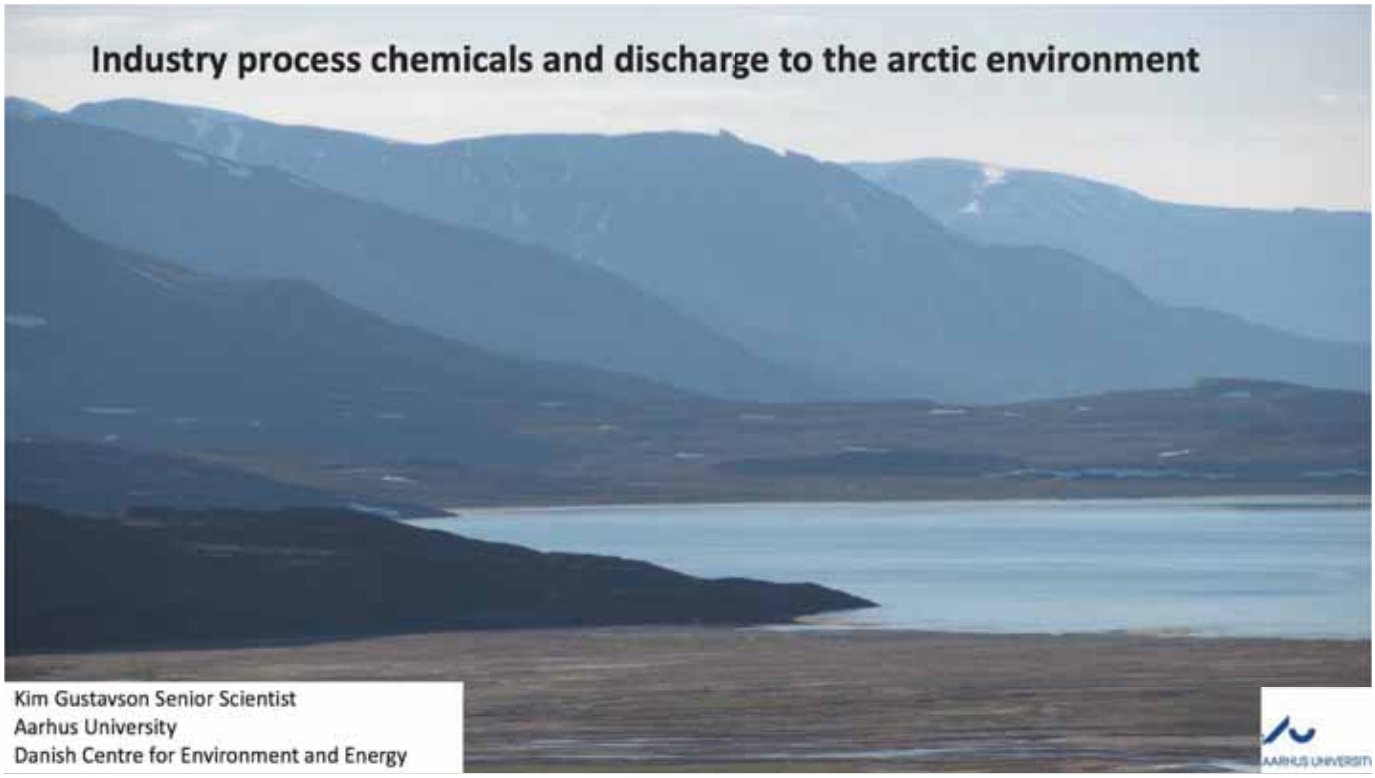
In a Greenland context, discharges of processed water from mining projects will in many cases result in discharges to the marine environment. The marine environment in the Arctic regions is characterized by low water temperatures and low concentrations of nutrient salts. Both are conditions that will limit or prolong the degradation of chemicals and other substances. In addition, the organisms and food chains are characterized by slow growth and a high content of lipids, which increases the risk of bioaccumulation especially of lipophilic chemicals.

A central question is how regulation can aid to ensure that the use of processing chemicals will not result in negative effects and long-term burden on the arctic marine environment and organisms. Is it possible to apply the same classification and regulation to chemicals in Arctic mining projects as are being used under the OSPAR in relation to offshore oil and gas extraction? Can data from standard tests for biodegradability, bioaccumulation and toxicity be applied?

What uncertainties will there be in using data from standard tests for regulation under Arctic conditions?

Link to *Presentation*

Industry process chemicals and discharge to the arctic environment



Kim Gustavson Senior Scientist
Aarhus University
Danish Centre for Environment and Energy

Mining project in the planning phase

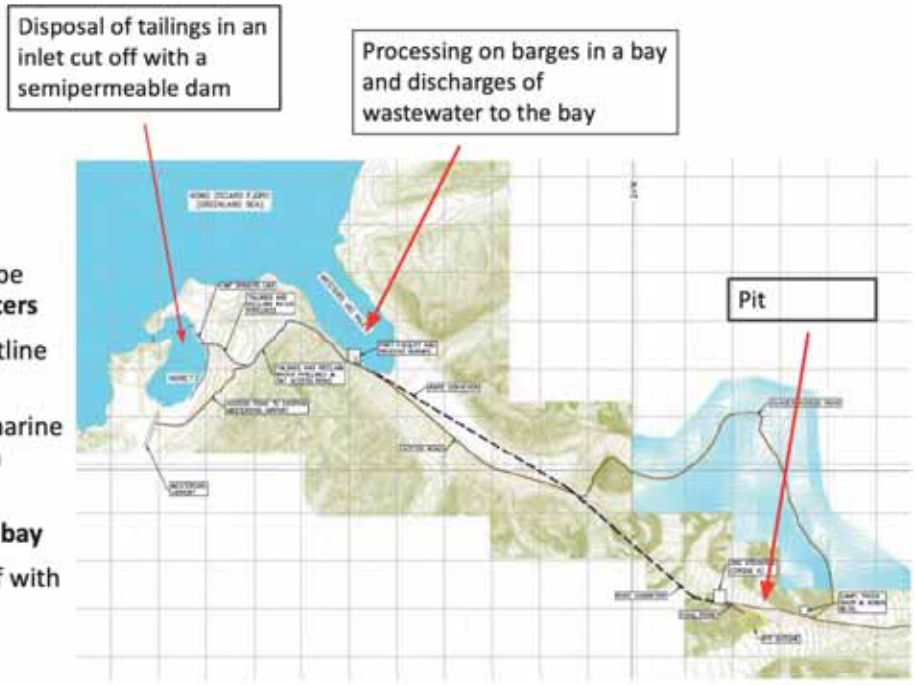
Most of the mines in Greenland will be **closely connected to the coastal waters**

Disposal of tailings close to the coastline or in the dam

Discharges of wastewater into the marine environment directly or indirectly via rivers.

Processing of the ore on barges in a bay

Disposal of tailings in an inlet cut off with a semipermeable dam.



Process Chemicals in Mining Project

- Chemicals added during **processing and enrichment of metals and minerals**
- The **needs of chemicals vary a lot from project to project,** depending on the mineralogy and elements extracted
- In terms of **environmental protection**, the use and fate of the chemicals used in mining projects are subjects that require attention!

Main types of chemicals used in the mining industry

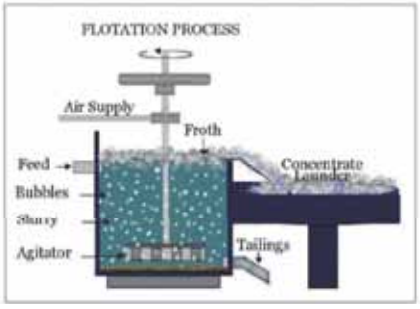
Flotation chemicals

Flotation chemicals are **necessary for enrichment of ore and minerals**

- Skimmers (allows simple formation of air bubbles)
- Collectors (adsorbs to the surface and makes hydrophilic particles hydrophobic)
- Regulatory substances (added to achieve full effect of skimmers and collectors)

Flocculation chemicals

Flocculation chemicals are used to recover water and to **reduce the water content in the tailings and increase flocculation of the fine fraction.**



Fate of the chemicals

Flotations Chemicals

- **Organic flotation chemicals** will mainly be skimmed off and follow the mineral
- **Inorganic flotation** chemicals will mainly follow the tailings.
- As a result, the organic flotation chemicals will **in principle not be discharged** to the recipient by wastewater or tailings.
- **However, as it is common practice to add an excess volume of flotation chemicals**, some of these will be discharged with the wastewater and tailings.

Flocculation Chemicals

- Flocculation chemicals are used by the mining industry to **increase sedimentation of fine-particulate material**. They are used for tailings in order to **recover fresh water** during the enrichment process.
- Flocculation of the fine fraction may be **related to wastewater or tailing.**

Example of products that a mining company recently like to use in a mining project in Greenland (>25 different products)

Reagent Function	Used for	Purpose	Annual consumption Tonnes
Zetag 8140 * Concentrator Flocculant	Zinc flotation	Thickener flocculant for zinc sulphide concentrate - to promote particle sedimentation to enable recovery of zinc product from process.	1.2 - 3.0
SNF FO4800H Concentrator Flocculant	REMC flotation	Thickener flocculant for REMC - to promote particle sedimentation to enable recovery of REMC from process.	150 - 400
Magnafloc 155 Refinery Flocculant (Anonic)	Impurity removal - Refinery	Thickener flocculant for anionic impurities - to promote particle sedimentation to enable removal of impurities in the refinery circuit.	75 - 180
Magnifloc 430 * Refinery Flocculant (Cationic)	Impurity removal and product recovery - Refinery	Thickener flocculant for cationic impurities and cationic products - to promote particle sedimentation to enable removal of impurities, and recovery of products in the refinery circuit.	20 - 60
RM1250 * Refinery Coagulant	Silica agglomeration	Thickener agglomerate for silica impurities - to promote agglomeration of fine silica particles to enable their removal from uranium product liquor.	60 - 160
Sodium iso-butyl xanthate (SIBX) Flotation Collector	Zinc flotation	To float the zinc sulphides, thereby separating these from the ore.	125 - 320
Copper sulphate ($CuSO_4.5H_2O$) Flotation Activator	Zinc flotation	To activate the surface of the zinc sulphide particles thereby improving the efficiency of their flotation.	25 - 60
Aero 6494 Flotation Collector	REMC flotation	To float the RE-bearing minerals, thereby separating these from the non-value mineral tailings.	1,000 - 2,700

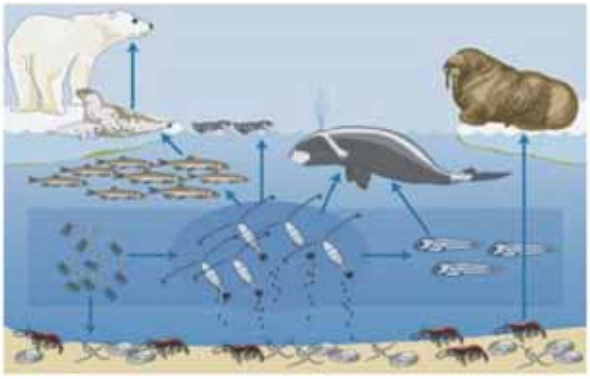
Reagent Function	Used for	Purpose	Annual consumption Tonnes
Sodium Silicate Flotation Depressant	Zinc and REMC flotation	Depressant - prevents the flotation of the non-value mineral tailings.	2,300 - 5,800
Polyfroth W22C Flotation Frother	Zinc and REMC flotation	To reduce the bubble size and increase froth stability in the flotation process.	110 - 280
Sodium Carbonate	REE product precipitation	To precipitate REE intermediate products from process liquors in the refinery circuit.	12,000 - 30,000
Sulphur	Sulphuric acid (H_2SO_4) production	To produce sulphuric acid, used to leach REEs and uranium from the REMC in the refinery circuit.	16,000 - 41,000
Sodium Chloride	Hydrochloric acid (HCl) and caustic soda (NaOH) production	To produce hydrochloric acid and caustic soda, used to respectively to leach REEs and to raise pH of process liquors (for product precipitation and impurity removal) in the refinery circuit.	35,000 - 87,000
Limestone	Impurity removal	To raise pH of process liquors in the refinery circuit.	30,000 - 77,000
Caustic Flake (NaOH)	Product precipitation and impurity removal	To precipitate cerium product, and to raise pH of process liquors in the refinery circuit.	1,400 - 5,000
Calcium Chloride	Water treatment	To precipitate fluoride from the treated water placement stream entering Nordre Sermilik.	6,900 - 17,500
Pyrolusite	REE leaching	To oxidise REE species during acid leaching process to improve REE recovery.	300 - 750
Haematite	REE leaching	To precipitate phosphate species during acid leaching process to improve REE recovery.	0 - 15,000
Hydrogen Peroxide	Product precipitation and impurity removal	To precipitate uranium oxide, and to precipitate impurities from refinery process liquors.	125 - 300

Reagent Function	Used for	Purpose	Annual consumption Tonnes
Lime	Impurity removal	To raise pH of process liquors in the refinery circuit.	3,800 - 9,500
Barium Chloride	Impurity removal	To precipitate impurities from refinery process liquors.	1,800 - 4,500
Sodium Hydrosulphide	Impurity removal	To precipitate impurities from refinery process liquors.	60 - 200
Alamine 336 * SX Extractant	Uranium SX	To extract uranium species from process liquors in the refinery circuit, thereby removing these from impurities and enabling production of pure uranium oxide.	2.5 - 10
Isodecanol * SX Phase Modifier	Uranium SX	To improve the solubility of the extractant in the organic diluent, thereby ensuring effective removal of uranium from the liquor phase.	1.0 - 5.0
PC-88A or Ionquest 801 * SX Extractant	REE SX	To extract REE species from process liquors in the refinery circuit, thereby removing these from impurities and enabling production of pure REE products.	70 - 175
Shellsol D70 * SX Diluent	REE SX	To provide the organic phase needed to carry the extractant, thereby ensuring effective removal of REEs from the liquor phase.	160 - 500
Uranium IX Resin CleanTeQ R6038	Impurity removal	To remove uranium impurities from the REE process liquor stream in the refinery circuit.	0.1 – 1.0
Accepta 2827/2302 Cooling Water Biocide	Cooling water treatment	To prevent the growth and build-up of microbiological organisms in the cooling water system, thereby ensuring optimum performance of process plant cooling systems.	140 - 500
Accepta 2319 Cooling Water Inhibitor	Cooling water treatment	To prevent the formation of rust in equipment associated with the cooling water system, thereby ensuring optimum performance of process plant cooling systems.	5 -30

Arctic Environment and Ecosystems

- Results from monitoring and research have shown that the **arctic ecosystems are very sensitive** to pollution with chemicals, oil substances, etc.
- **Slow degradation** of chemicals due the low temperatures and low concentrations of nutrients in arctic waters
- **Arctic organisms have a very high content of fat** for insulation against the cold climate and long winter periods without food.
- **High risk of bioaccumulation of lipophilic chemicals (substance with high affinity for fat) in arctic organism**
- Slow growth cause **long recovery time**

Arctic ecosystems are characterized by **simple food chains and a high content of fat**



Environmental Concern in relation to use of chemicals in mining

Concerns

Significant volumes of chemicals, in particular flotation chemicals, are used and it is therefore important to ensure these are:

- Biodegradable
- Not toxic (acute or chronic)
- Do not bioaccumulate in organisms

Protection of the environment

Use chemicals with

- low toxicity
- low potential for bioaccumulation
- easily degradable in nature

Minimize the release and discharge of chemicals to the environment

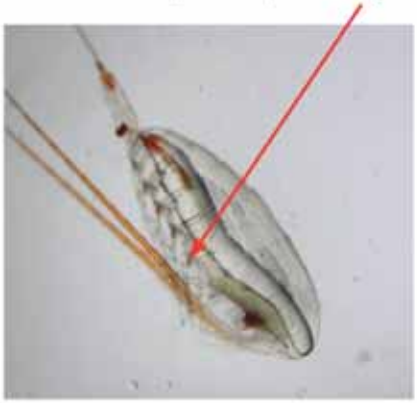
All use of chemicals **should be approved by authorities** before use

Recommendation

- Classification of chemicals provides **important information on hazard properties**
- All use of chemicals **should be approved by authorities** before use
- **We recommend to use OSPAR classification** to chemicals as also used for offshore oil and gas extraction
- **Replace environmentally hazardous product/chemicals** with less hazardous should be sought
- **If needed tests** should be performed under arctic conditions and with arctic organisms.
- All substances in products should be evaluated

High Arctic Copepod

Lipid sac up to 40% of the body weight



*The relative **larger size, longer life and larger lipid sac** of the high Arctic Copepod are generally **assumed to be adaption to the strong seasonality of the high Arctic***

Thanks for your attention!

Eelgrass in Greenland- Mapping of distribution and vulnerability in relation to seabed material extraction

Speaker: Dr. David Blockley, Greenland Institute of Natural Resources

Biography: *Dr. Blockley provides advice to government regulators and conducts research related to marine impacts from mining and hydrocarbons exploration. Additional research includes impacts of sea level changes on subtidal benthic ecosystems, monitoring long term biological indicators of climate change and ecotoxicology.*

What is the Purpose of your Talk?

Environmental impacts, monitoring and assessment for impacts of shallow coastal mining on marine vegetation.

Abstract:

Eelgrass is the only flowering plant that grows in the sea around Greenland. In the fjord near the capital, Nuuk, eelgrass forms geographically isolated populations of plants in the inner-most and warmest fjord arms. Eelgrass meadows have an important function as habitats and food sources for a wide range of organisms, and thus can support a rich animal and plant life on an otherwise species-poor sandy bottom. However, the distribution and growth of eelgrass in Greenlandic fjords is limited by the low sea temperatures and so the quantitative importance is not as great as in more temperate environments. Nonetheless, eelgrass is categorized as "vulnerable" on the Greenlandic endangered species list and is at risk from anthropogenic disturbance.

One of the most notable risks to eelgrass meadows in Greenland is from the seabed extraction of sand and gravel via ships equipped with a suction pipe lowered onto the seabed. A slurry of water and materials are pumped from the seabed up into the ship, with excess water and fine material continuously discharged over the side. This process can leave holes up to 10 m deep and about 30 m in diameter and can result in the absorption of organisms and destabilization of the seabed. The discharge water containing fine sediments forms a plume which makes the water opaque, reducing light penetration, potentially limiting growth of marine plants. Eventual settlement of the plume may also smother bottom dwelling organisms.

Mapping of the distribution of eelgrass was carried out at the sites where a permit for dredging had been applied for and where there was also an expectation of eelgrass occurrence. To assess the actual distribution of eelgrass in the relevant locations, a handheld underwater video camera was used to record the seabed and the presence of eelgrass. At all the sites studied, in Kobbefjord and in Ameralik Fjord, the occurrence of eelgrass was confirmed in sand habitats adjacent to current or potential dredging activity.

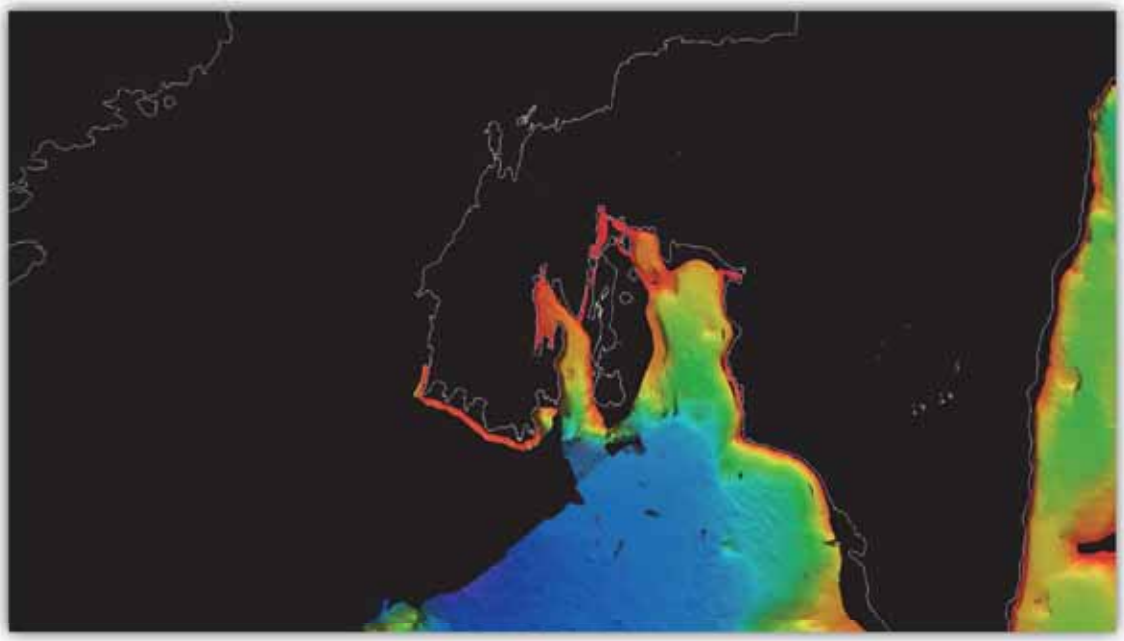
To ensure the protection of eelgrass, it is recommended that dredging be carried out only with a safety distance of 500 meters from identified eelgrass meadows to protect plants from physical damage or impacts from increased silt. Future work would further refine and map the distribution of eelgrass in relation to all dredging activity. There is also a need for

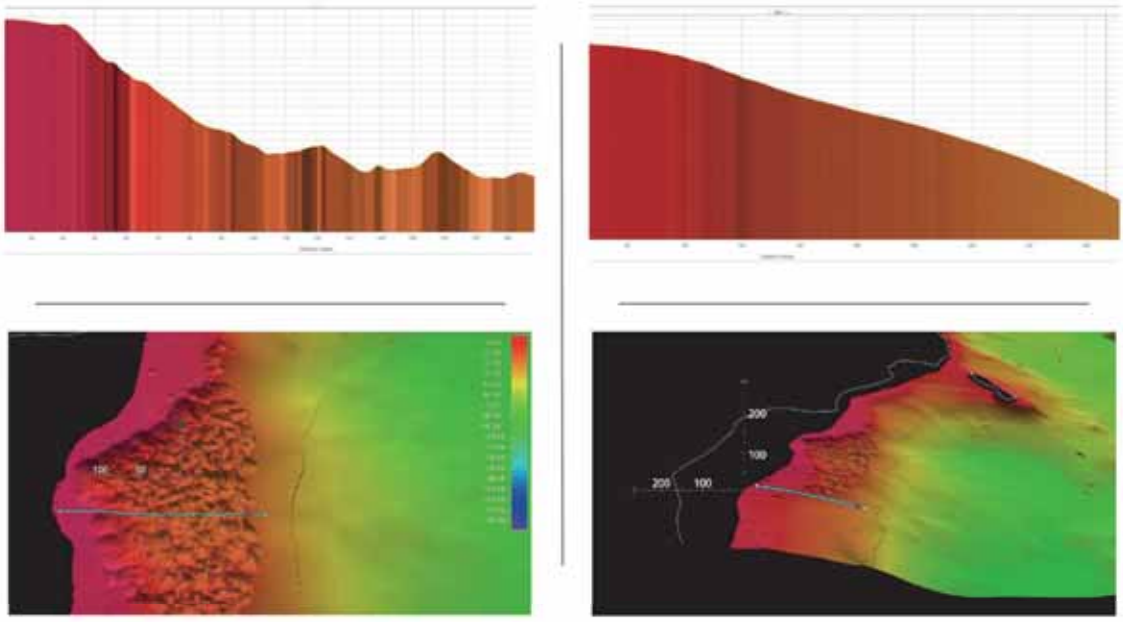
monitoring programmes to determine temporal trends in distribution and to understand any impacts from ongoing dredging activity.
Link to *Presentation*

Eelgrass in Greenland

Mapping of distribution and vulnerability in relation to seabed material extraction

Dr David Blockley

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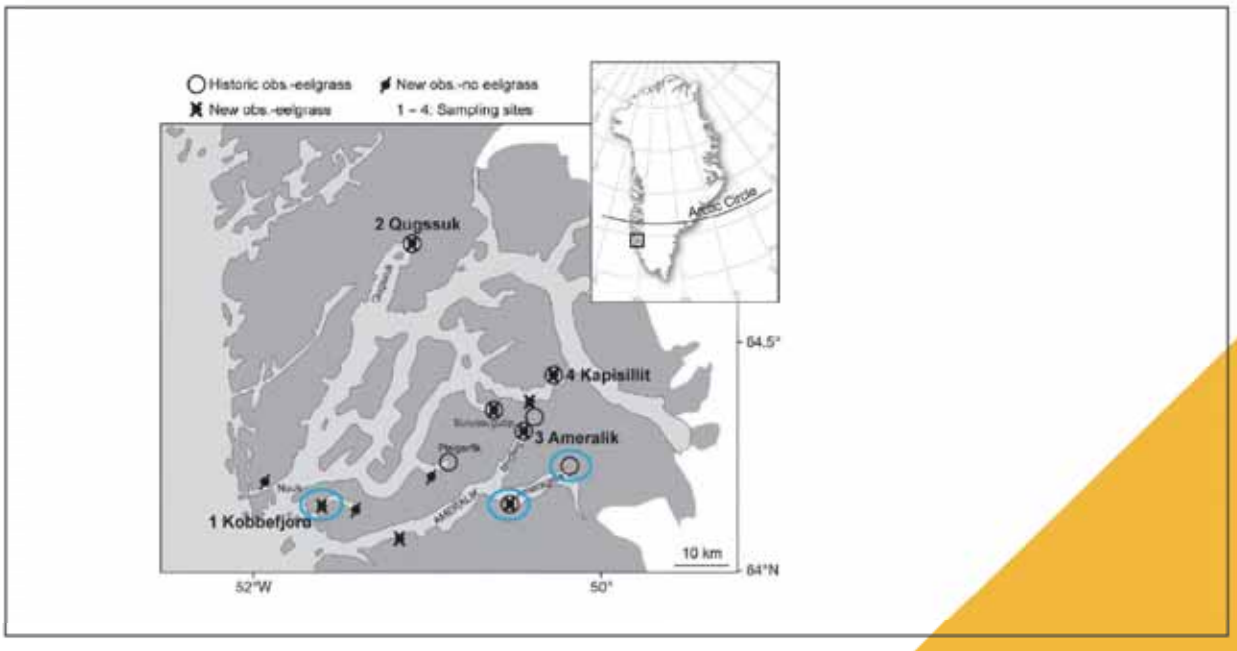
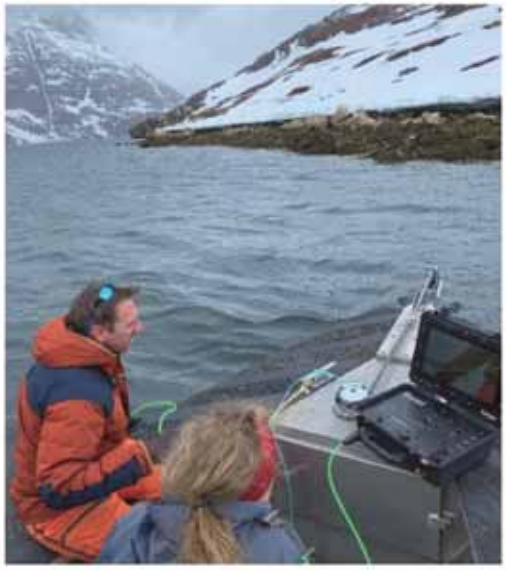

Historic obs.-eelgrass
New obs.-eelgrass
New obs.-no eelgrass
1 – 4. Sampling sites
Arctic Circle
2 Qugssuk
4 Kapisillit
3 Ameralik
1 Kobbefjord
10 km
52°W
50°
64.5°
64°N

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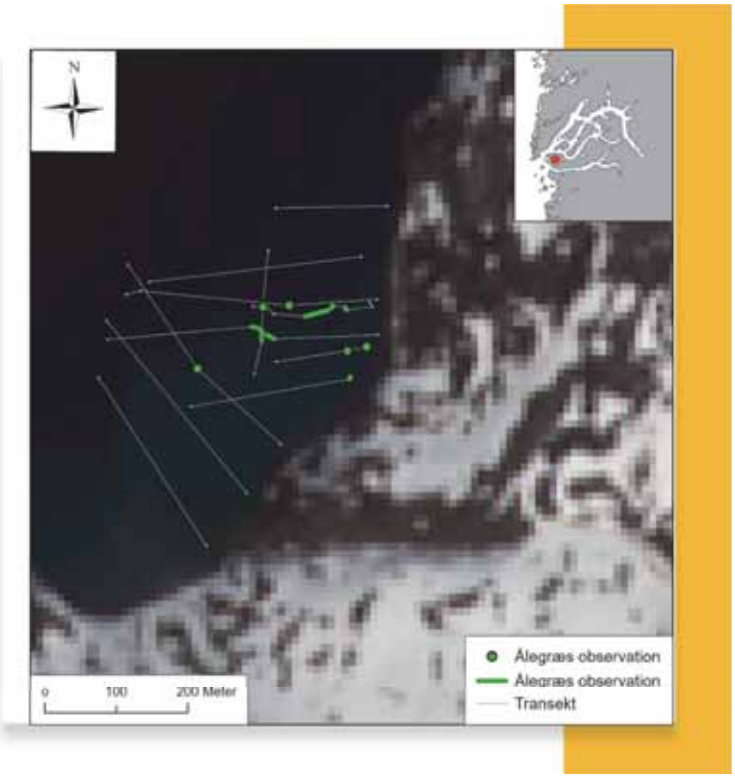
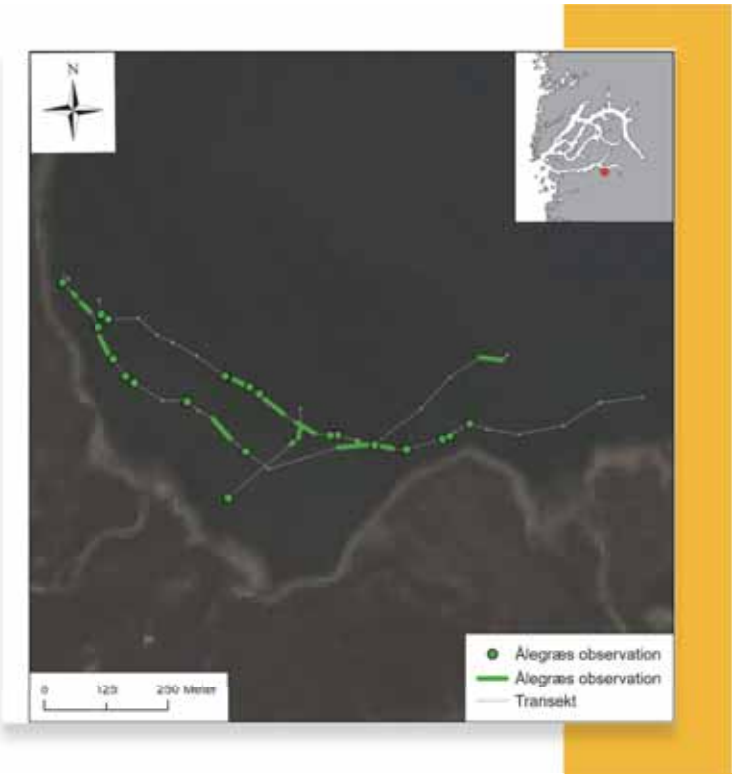
Kobbefjord

Max distance from land: 180 m
Max depth: 5 m



Ameralik Fjord – Eqaluit Ilorliit

Max distance from land: 290 m
Max depth: 8.4 m



Ameralik Fjord – Kilaarsafik

Max distance from land: 270 m

Max depth: 4.8m

Recommendations

- Dredging is carried out only with a safety distance of 500 meters from eelgrass.
- This safety distance is set to:
  - ensure that the leaves and root stalks of eelgrass are not damaged through burial by sediment discharged as a by product of sand dredging;
  - ensure that the increase in turbidity from discharge/spillage of silt particles is sufficiently diluted so that photosynthesis/growth is not inhibited;
  - consider the uncertainty in the mapping of eelgrass deposits;
  - prevent the risk of destabilisation of bottom conditions;
  - ensure that eelgrass can spread and consolidate.
- Establish a monitoring programme so that changes in distribution and possible effects on eelgrass are monitored and recommendations adjustment in response.
- Mapping the possible occurrence of eelgrass if extraction of seabed materials occurs at locations with a depth of less than 10 meters.

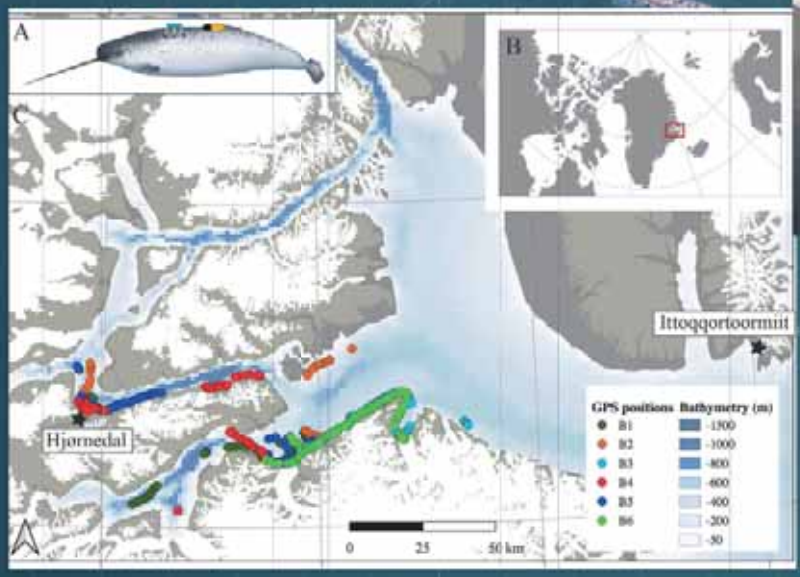
Session 2B) What can we do better to maintain biodiversity: Exploring challenges, approaches and solutions

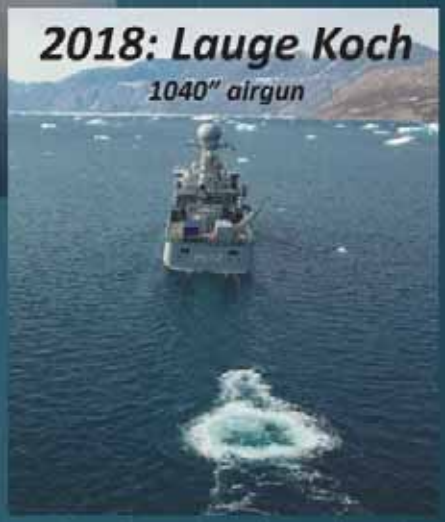
Narwhals and underwater noise: New knowledge
Speaker: Mads Peter Heide-Jørgensen, Greenland Institute of Natural Resources and the University of Copenhagen
Biography: *MPHJ is a professor in marine biology at the Greenland Institute of Natural Resources and the University of Copenhagen. He has worked with North Atlantic marine mammals for over 40 years and has pioneered several novel techniques for collecting biologging data from marine mammals, including a variety of methods for satellite tracking whales. He is a permanent member of the Scientific Committee of North Atlantic Marine Mammal Commission.*
What is the Purpose of your Talk? To present the latest experimental data as well as real-time information on effects of noise on narwhals
Abstract: The effects of ship noise and small seismic air guns on narwhals has been studied in a controlled dose experimental setup in East Greenland. Narwhals proved to be extremely sensitive to disturbance, changing speed and swimming direction at distances of up to 24 km from moving vessels. Other behavioral responses included a reduction of feeding and cessation of deep dives. Physiological responses included marked cardiovascular, respiratory and locomotor reactions. Some of the reactions were triggered at distances larger than 40 km from the ship. There were no indications of narwhals being habituated on the short term after repeated exposures to ship noise. A large-scale effect of disturbance of narwhals has been observed in connection with increasing ship traffic over several years to and from the Mary River mine in coastal areas of northern Canada. The most serious observed effect was a massive displacement of narwhals out of Eclipse Sound and into Admiralty Inlet. It has been estimated that about 25.000 narwhals have emigrated from the Eclipse Sound population to the neighboring Admiralty Inlet, with no more than 2.000 narwhals left in 2021. There is no evidence suggesting that the displacement could have other causes like climate change or increased predation from killer whales.
Link to *Presentation*

Narwhals and underwater noise; new knowledge

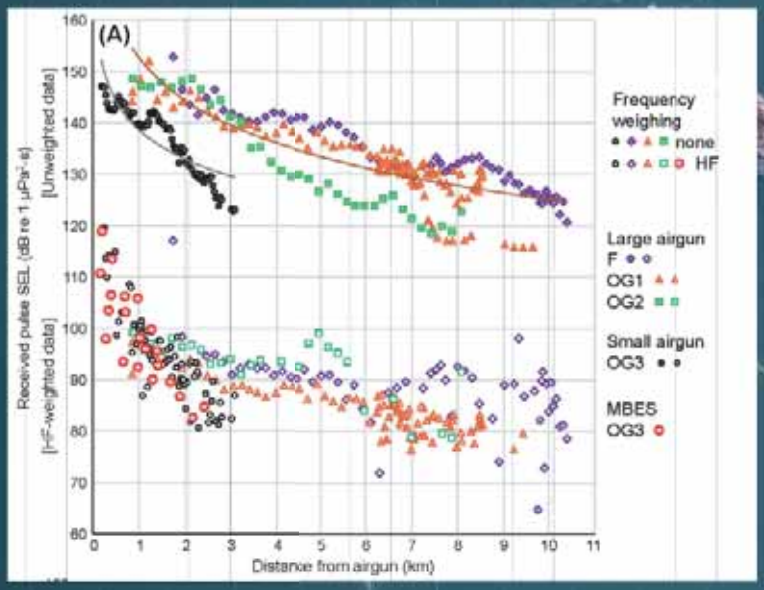
MP Heide-Jørgensen, Professor, Dr. Scient.
Greenland Institute of Natural Resources

Controlled dose study in the world's largest fjord system

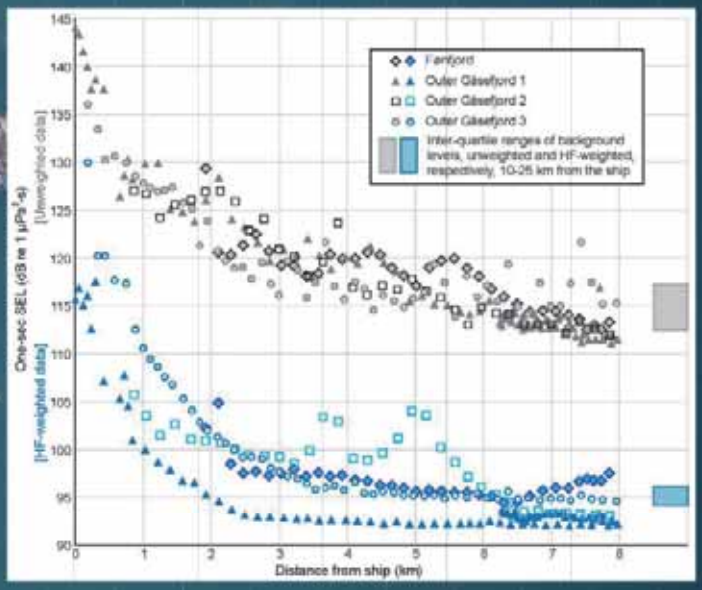




Airgun pulses



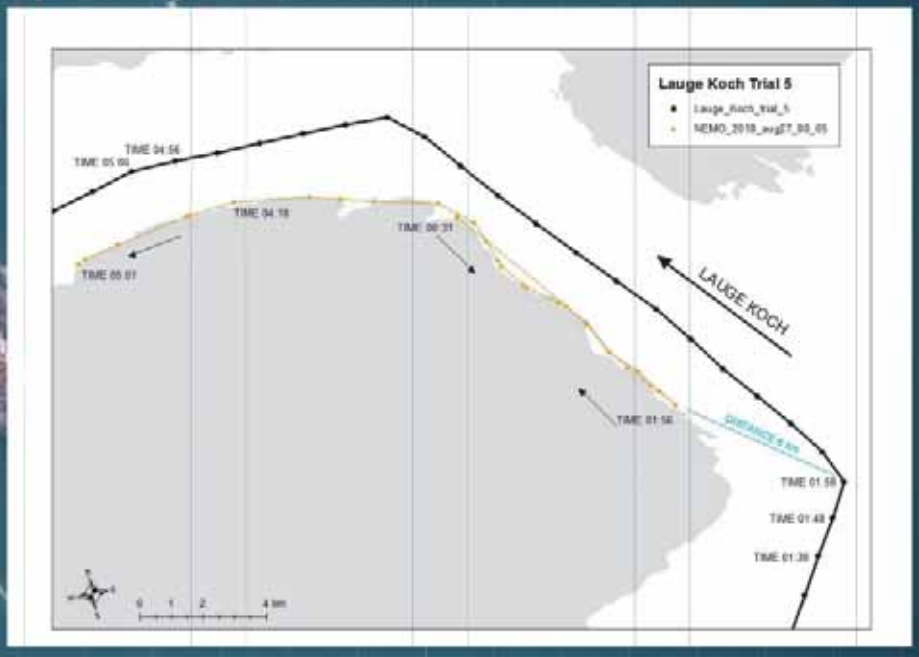
Ship generated noise



Heide-Jørgensen et al. 2021. Frontiers in Marine Science.

Sample of reaction 1

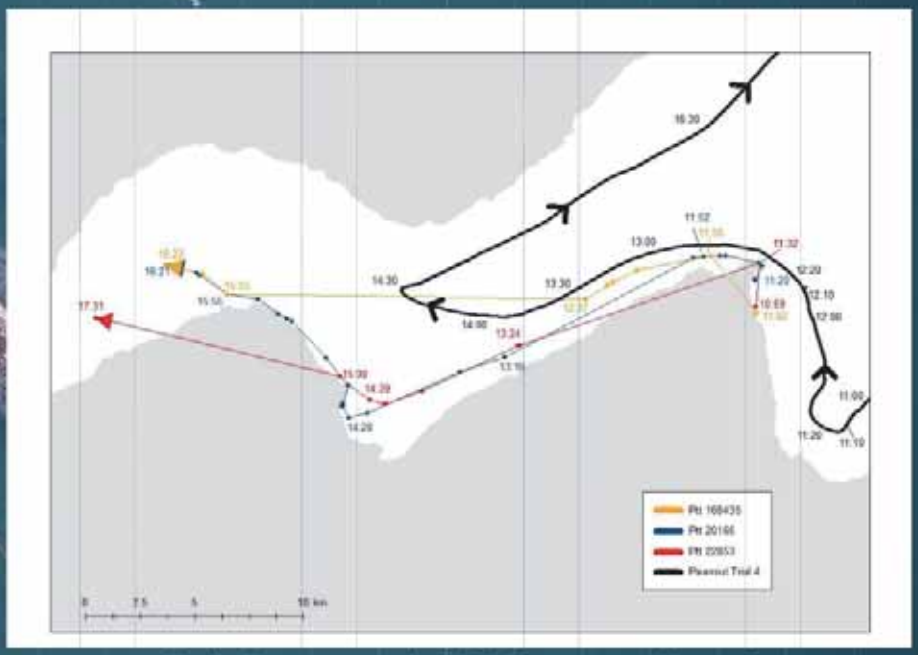
Whale at coast
Short distance reaction
Escape parallel to ship



Heide-Jørgensen et al. 2021. Frontiers in Marine Science.

Sample of reaction 2; continued response

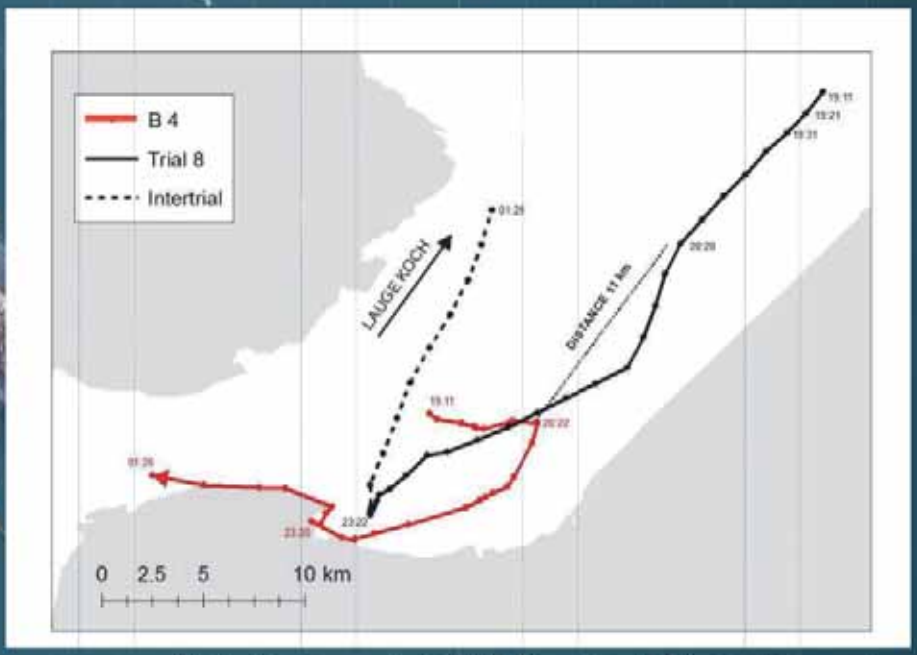
Whale at coast
Short distance reaction
Reaction without LOS
Continued reaction



Heide-Jørgensen et al. 2021. Frontiers in Marine Science.

Sample of reaction 3; offshore

Whale offshore
Long distance reaction
Moving towards shore
Continued reaction



Heide-Jørgensen et al. 2021. Frontiers in Marine Science.

Before:
- Whale off the coast
- Diving >400m
- Buzzing

Intertrial:
- No deep dives
- No buzzing

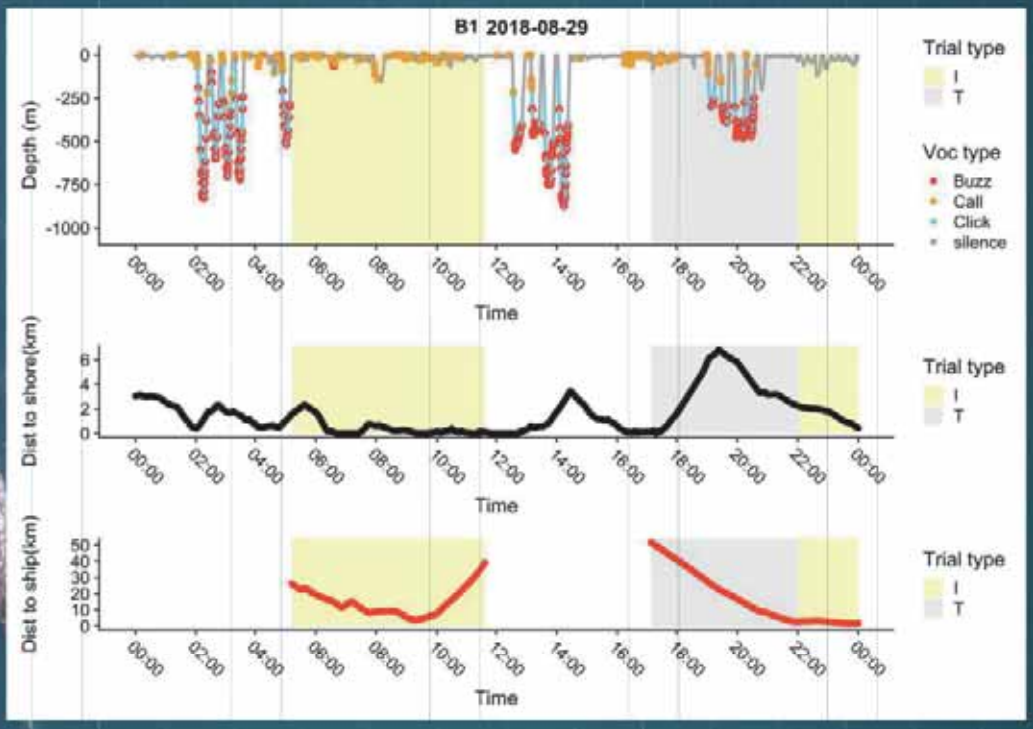
Off line of sight:
- Diving resumed
- Buzzing resumed

Seismic >50km:
- Buzzing
- Dives <500m

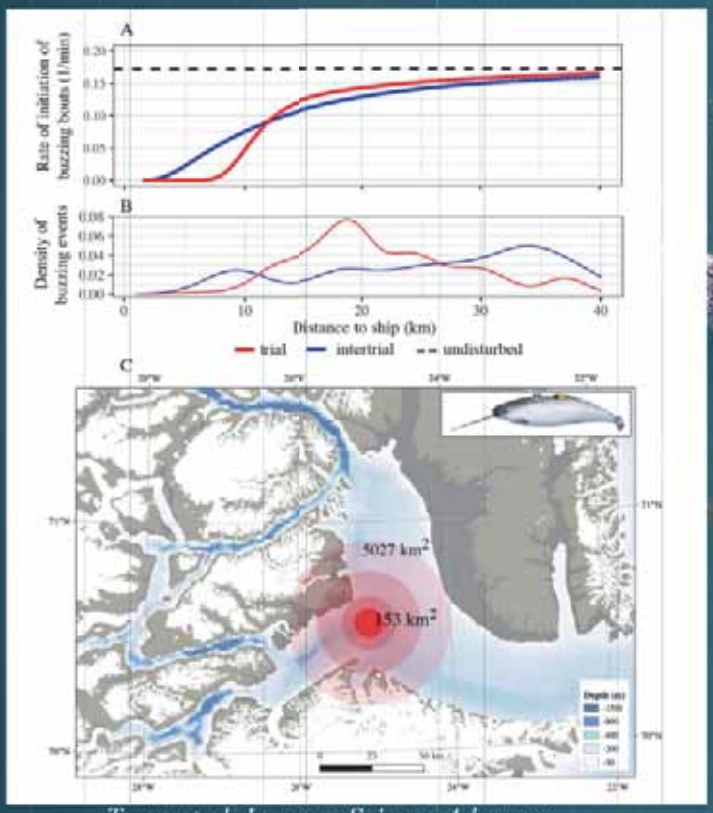
Seismic <30km:
- Towards shore

Seismic <10km:
- No buzzing
- Towards shore

Intertrial:
- No buzzing
- No deep dives
- Towards shore



Heide-Jorgensen et al. 2021. Frontiers in Marine Science. https://doi.org/10.3389/fmars.2021.658173



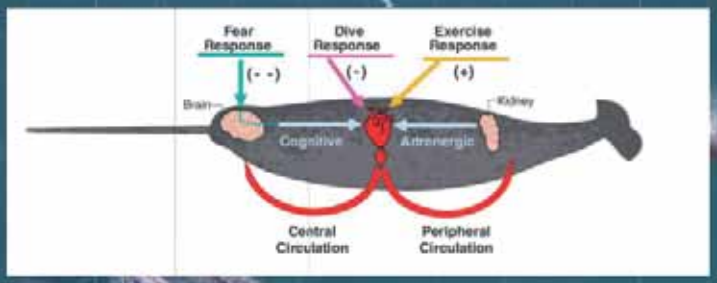
Tervo et al. In press. Science Advances

Loss of vocal activity

=

and loss of foraging

Cascade of physiological responses

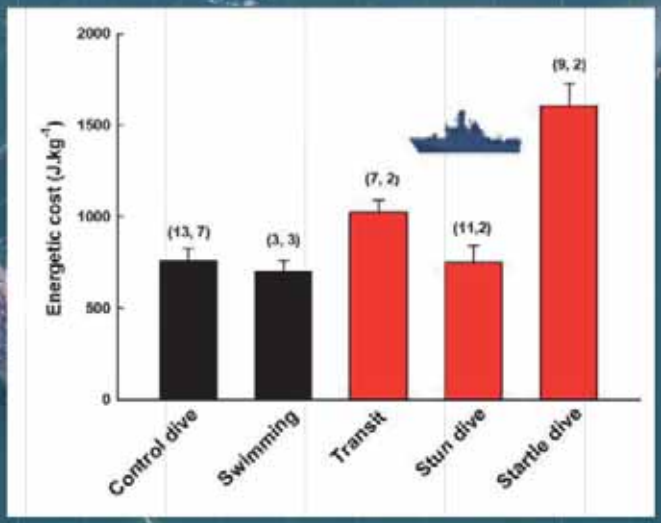


During exposure:

- 80% reduction of duration of gliding
- Prolonged high intensity activity with elevated stroke frequencies >40 strokes per minute
- Intense (< 10 bpm) bradycardia decoupled from stroking frequency
- Increased variability in heart rate, switching between bradycardia and tachycardia
- Maximum respiratory frequency 1.5 times control levels.
- In total a 2.2-fold increase in energetic costs while suppressing cardiac exercise response

Williams et al. 2021.Functional Ecology.

Energetic costs of disturbance



Williams et al. 2021.Functional Ecology.

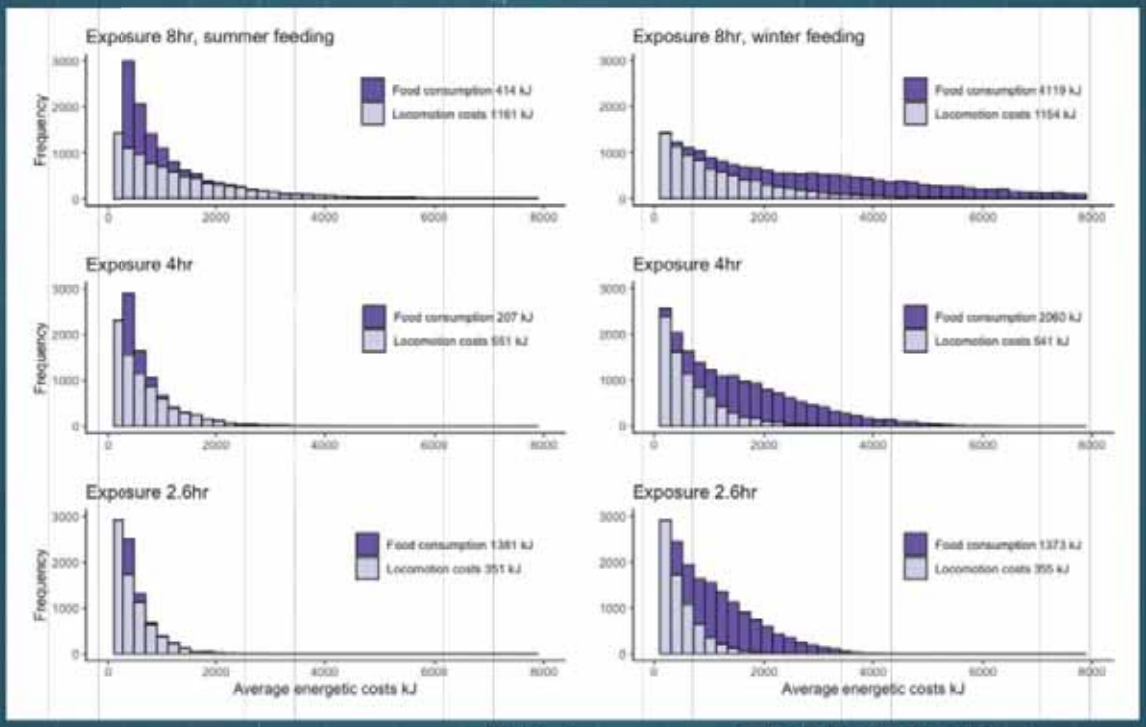
Extreme sensitivity

Effects on:

- swimming speed
- distance to shore
- buzzing rate
- diving patterns
- cardiac performance
- energetics

Reactions are context specific
Source of disturbance appears less important
Habituation could not be detected
Individual sensitivity can be extrapolated to population level

Energetic costs per ship passage



Heide-Jorgensen et al. 2022. NAMMCO Meeting.

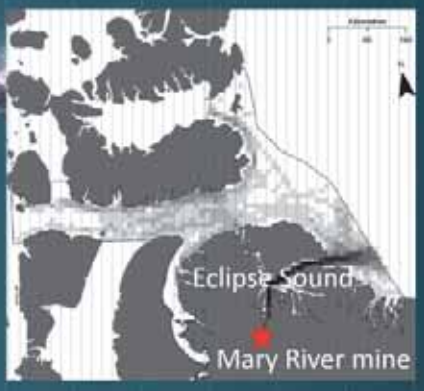
The Mary River Project: a real-world experiment

BULK CARRIER TRAFFIC

to and from the Mary River Mine

Bulk carriers transport cargoes in large quantities, like food grains, ores, coal, and cement.

2013 2019

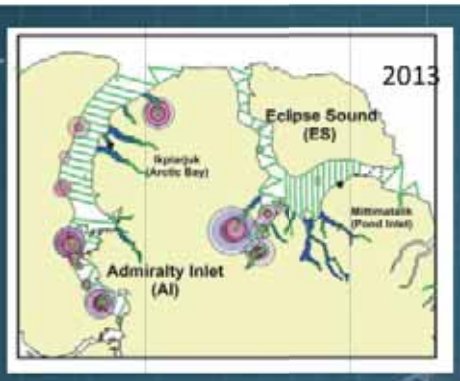


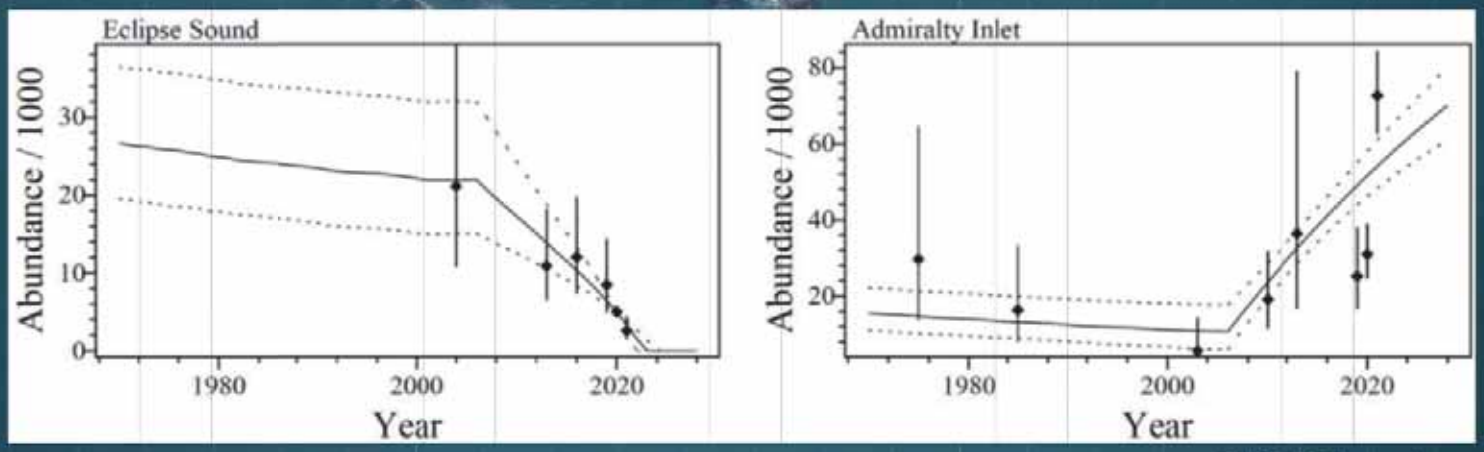
3.5 million tonnes iron ore per year

188 one-way transits of project-related ships occurred during July-October 2020, with icebreakers used early and late in the season.

Kochanowicz 2021. Marine Policy

An unprecedented shift in abundance





NAMMCO meeting


NAMMCO
JOINT DISTURBANCE WORKSHOP
OF THE
NAMMCO SCIENTIFIC COMMITTEE WORKING GROUP ON THE POPULATION STATUS OF NARWHAL AND BELUGA IN THE NORTH ATLANTIC
AND THE
CANADA/GREENLAND JOINT COMMISSION ON CONSERVATION AND MANAGEMENT OF NARWHAL AND BELUGA SCIENTIFIC WORKING GROUP
REPORT
Available from NAMMCO
https://nammco.no/

A Saami approach to maintaining biodiversity in marine environments affected by mining*

Speaker: Tonje M. W. Johansen, Saami Council

Biography: *Tonje Margrete Winsnes Johansen is an advisor at the Saami Council's Arctic and Environmental unit. In her work, she focuses mainly on societal issues in Sápmi and the societal aspects of a changing climate and environment.*

Abstract: What is the Purpose of your Talk?

The need for minerals must be assessed against the consequences for nature, biodiversity, nature-based livelihoods, and social development.

Indigenous rights need to be the basis when decisions on mining licenses are made to avoid breaching human rights.

The world's richest countries should be at the forefront of developing and demanding as environmentally friendly mining as possible, particularly in vulnerable ecosystems such as those in the Arctic. This does not include dumping mining waste in the ocean.

The very same countries should also lead the way in transforming the economy into a circular one and raising the issue of everlasting growth.

The Saami Council wants with this talk to challenge the countries that the Sámi people live within to be role models when it comes to mining in Indigenous land, including marine areas.

*Denotes oral presentation given without visual tools.

Session 3A) What can we do better on regulating the impacts of Arctic mines, and meaningfully engaging Indigenous Peoples and local communities?

Towards Sustainable Mining; an overview
Speaker: Katherine Gosselin, Mining Association of Canada
Biography: *Katherine is the Director of the Towards Sustainable Mining (TSM) program, a globally recognized standard for sustainability in the mining sector. She supports the adoption and implementation of TSM by Mining Association of Canada members and other national mining associations. She holds an MSc in Global Politics from the London School of Economics and Political Science.*
What is the Purpose of your Talk? To provide a brief overview of TSM – *Towards Sustainable Mining* – a global mining sustainability standard that helps companies manage social and environmental risks.
Abstract: TSM has been helping mine sites manage, report, and verify their sustainability performance since 2004. Today, more than 200 mining companies around the world implement the TSM program, which sets rigorous standards for environmental and social risks, such as tailings management, water stewardship, and relationships with Indigenous peoples. The program is currently implemented in several Arctic jurisdictions, including Canada, Finland, and Norway. The aim of this talk is to improve awareness of this widely adopted standard for sustainability in the mining sector.
Link to *Presentation*

Towards Sustainable Mining

An overview

- **An ESG standard that helps mining companies evaluate and manage their environmental and social responsibilities**
- **Mandatory for all mining companies that are members of TSM associations**
- **Overseen by a network of national advisory panels**
- **Implemented by over 200 companies globally**

TSM Abroad

TSM consists of seven core components:

1. **Guiding Principles**
2. **Performance Indicators**
3. **Facility Level Reporting**
4. **Independent Verification**
5. **Public Reporting of Facility Level Reporting**
6. **Condition of Membership**
7. **Community of Interest Advisory Body**

Network of National Community of Interest Advisory Panels

- **Each TSM association must establish a national advisory body**
- **In Canada, the panel includes individuals from:**
  - **Indigenous groups**
  - **Mining communities**
  - **Environmental and social NGOs**
  - **Academia**
  - **Labour**
  - **Financial organizations**
  - **Members of the Mining Association of Canada's**

- **Biannual meetings**
- **Annual reviews of company performance**
- **Critical perspectives on emerging issues**

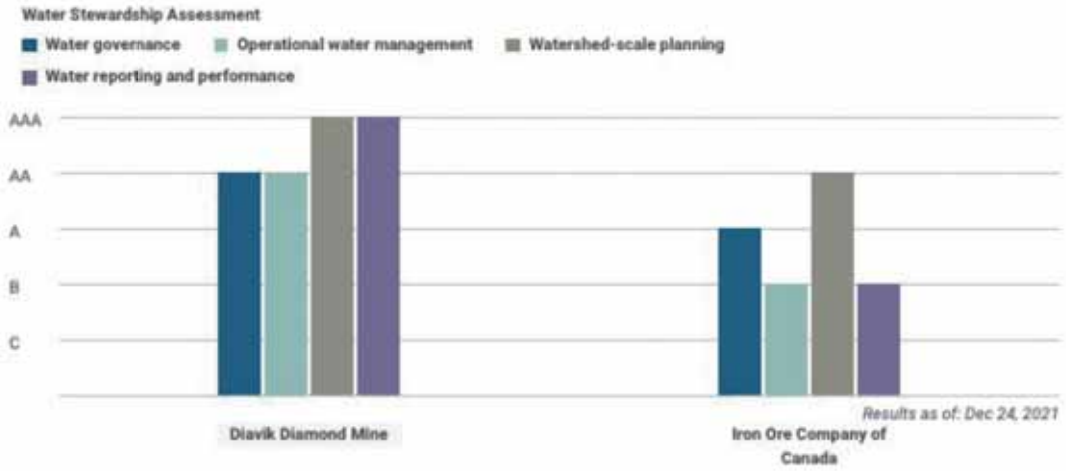
TSM Protocols

Communities & People

Environmental Stewardship

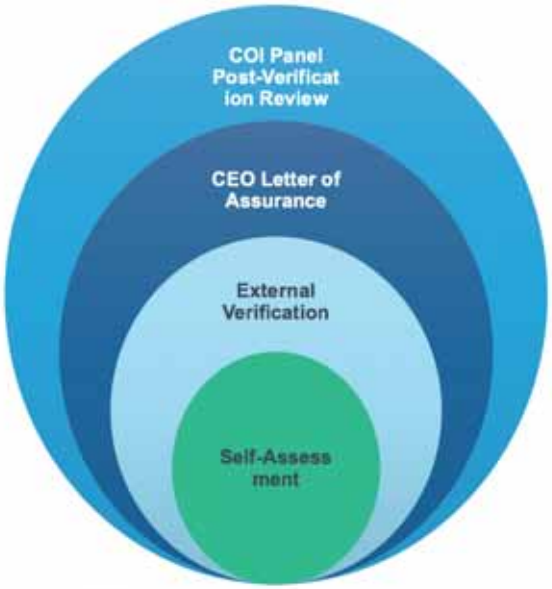
- Tailings Management
- Biodiversity Conservation Management
- Water Stewardship
- Climate Change
- Indigenous and Community Relationships
- Safety and Health
- Crisis Management and Communications Planning
- Preventing Child and Forced Labour
- *Equitable, Diverse, and Inclusive Workplaces (in development)*

Annual Public Reporting by Facilities



Verification Process

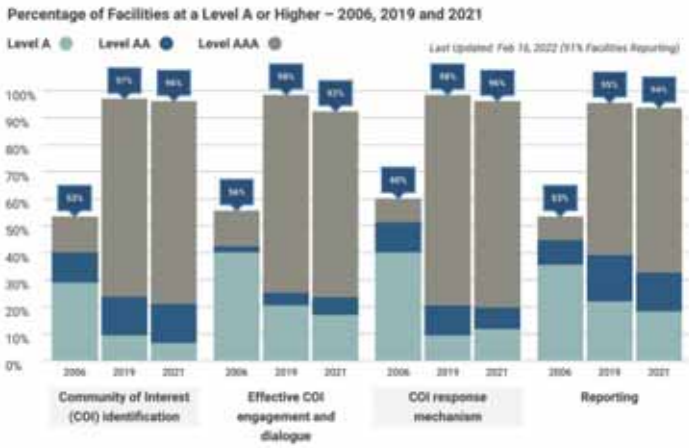
- Annual self-assessments externally verified every three years
- Public verification summary reports
- Notice of verification to communities and community interviews by verifiers
- Letter signed by CEO to confirm accuracy of verified results and conformance with requirements
- Potential selection by the



Continual Improvement

- Improvements in industry performance are measurable and meaningful over time
- Companies commit to demonstrate continual improvement until they achieve good practice

Indigenous and Community Relationships



External Verifications by TSM Partner Associations

Tulokset

Vuonna 2021 todennetut tulokset

Results for Boliden Kevitsa Mining

Results verified in 2021

Standards Alignment

- **The *TSM Responsible Sourcing Alignment Supplement*, allows companies to use their TSM performance, with some additional criteria, to meet:**
  - **International Council on Mining and Metals' Mining Principles**
  - **International Copper Alliance's Copper Mark**
  - **World Gold Council's Responsible Gold Mining Principles**
  - **Responsible Minerals Initiative's Risk Readiness Assessment**
  - **ResponsibleSteel**
- **The *Mining Minerals and Metals Partnership Integrated Assessment Protocol* allows mines to be assessed against multiple site-level standards (TSM, IRMA, RJC) in a single audit.**

Discovering and delivering commodities for our future, in Greenland and Finland
Speaker: Bo Stensgaard, CEO, Blue Jay Mining
Biography: *Dr. Stensgaard is a Danish national and preeminent geologist with extensive operational experience in Greenland. Bo was a senior research scientist at the Danish state survey and has advised multiple European federal and commercial entities in the field of commodity development.*
Abstract: Bluejay Mining has been an industry leader in growth and research into new concepts and practices. A case study of the Dundas project will analyze several new concepts and practices in use that aim to create projects that are: lower risk, realizable, and resilient.
Link to *Presentation*

Bluejay mining plc

Discovering and Delivering Commodities for our Future, in Greenland and Finland

Arctic Mining: Environmental issues, mitigation and pollution control for marine and coastal mining

March 23rd 2023

Bluejay Mining CEO Bo M. Stensgaard

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Bluejay Snapshot

Premium resource portfolio in Greenland & Finland

Disko-Nuussuaq (Ni-Cu-Co-PGM-Au)

KoBold Metals

- Potential to host a **new world-class nickel deposit – analogues to Noril'sk Nickel District.**
- District-scale multiple targets over 2,776km² licence area.
- Massive nickel-sulphide mineralised boulder ran 6.9% Ni, 3.7% Cu, 0.6% Co, 2g/t PGM*.
- **Drill ready targets.** >30-years of historical datasets.
- **US $ 15m JV with KoBold Metals** for exploration & drilling related activities (to earn-in up to 51%).
- Ongoing programme.

Dundas (ilmenite sands - titanium)

CONFIDENTIAL PARTNER

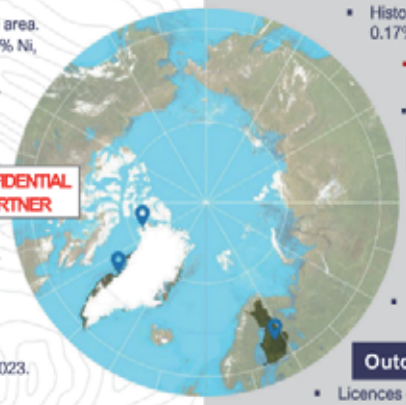
- **Large-scale mineral sand mining project.**
- **Fully permitted 30-yr** Exploitation Licence granted.
- Certified EIA & SIA to highest ESG standards.
- **Offtake Agreement signed for up to 340,000 tpa** (80% of planned annual production).
- Lead arranger appointed for project financing.
- Revised Mineral Resource Estimate expected mid-2023.
- **Feasibility Study underway.**

Kangerluarsuk (Zn-Pb-Ag-Cu)

- Targeting sediment-hosted Zn-Pb-Ag ± Cu deposits.
- 692km² licence **adjacent to the former high-grade Black Angel Zn-Pb-Ag mine** (produced 11.2 MT @ 12.6% Zn, 4.1% Pb and 29 g/t Ag)*.
- **Funded 2023 drill season (US $ 2m) to commence on identified targets.**

Thunderstone (Au and base metals)

- Regional licence (920 km²) – **true greenfield region; 1st phase completed.**



Enonkoski (Ni-Cu-Co-PGM)

RioTinto

- Licences cover entire prospective belt that hosts two former Ni-Cu mines.
- Historic drill intercepts include: 32.90m @ 4.09% Ni, 0.56% Cu, 0.17% Co and 19.70m @ 6.12% Ni, 1.94% Cu, 0.29% Co*.
- **US $ 20m JV with Rio Tinto** for exploration and drilling related activities (to earn-in up to 75%).
- Ongoing programme.

Hammashlathi (Cu-Zn-Au-Ag)

- High-grade VMS mineralisation. Licences cover **entire prospective belt.**
- **Former open-pit & underground mine** produced +10 Mt @ 1.16% Cu, 1.55% Zn, 0.59 g/t Au and 5.2 g/t Ag between 1973-86*.
- Extensions to the mined orebody demonstrated by recent drilling, and several near-mine geophysical targets. **Drill ready.**

Outokumpu (Cu-Co-Zn-Ni-Ag-Au)

- Licences cover the majority of the Outokumpu copper belt, **a prolific mining district.** High-value commodity basket.
- Several former high-grade mines – entire Outokumpu Belt produced 44Mt @ 3.1% Cu. The Outokumpu (Keretti) and Vuonos Mines produced combined 34.4 Mt @ 3.6% Cu*.
- **New near-mine and along strike targets; drill ready.**

Black Shales Project (Ni-Zn-Cu-Co)

metals one

- **Partial divestment** of Paltamo and Rautavaara licenses in Finland to Metals One plc - cash and shares of **US $ 5m.**
- Bluejay will appoint a technical director to the board.

Listed on London AIM ("JAY")
US OTC ("BLLYF") and Frankfurt ("35WA") Exchanges.
Current Market Capitalisation of c. £40.2M GBP

£/€

Strong institutional backing
& Greenlandic & Danish Government backed institutional investors

SAND GROVE
M&G
WEKSTFONDEN

Skilled Board, Management & Consultancy teams. Strong experienced in-country resources, develop and operational expertise
linked with business and commodity market expertise

March 2018: Prospector and Developer of the Year 2017 by Government of Greenland
High ESG Standards
Trusted local partner

*Non JORC Compliant

NORTH-WEST GREENLAND

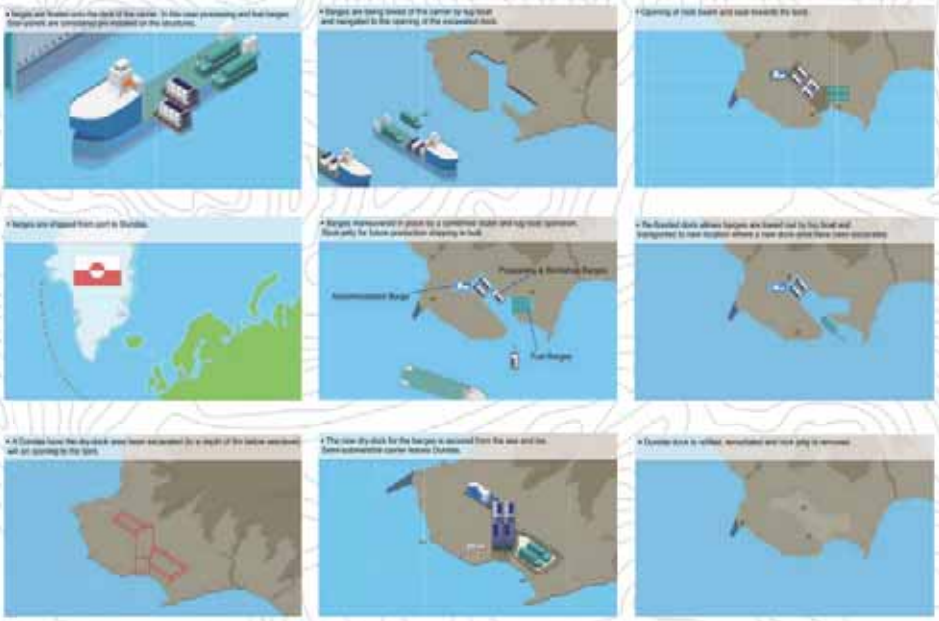
The Dundas Ilmenite (Titanium) Project

Large-scale, fully permitted project

Dundas Story Board
Mine Construction, Production, Re-location & Reclamation

- New concept: Dry-docked barge-based processing plant and infrastructure with fabrication and commissioned off-site Dundas.
- Additional new concepts in the project: Conveyor systems, new more simple mining method and alternative method for ore preparation stage. Renewable energy being considered.

➢ **Lower risk, realisable and resilient project.**



Dundas Ilmenite Project

Dundas
Mine Construction, Production, Re-location & Reclamation

DUNDAS TITANIUM

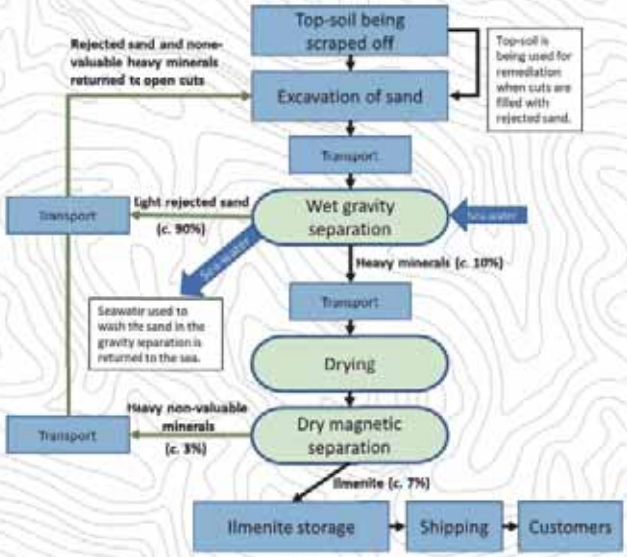
DUNDAS TIANTIUM A/S
– Dry-dock barge concept presentation –

December 2022 – concepts under development *[vers. Dec. 2022]*

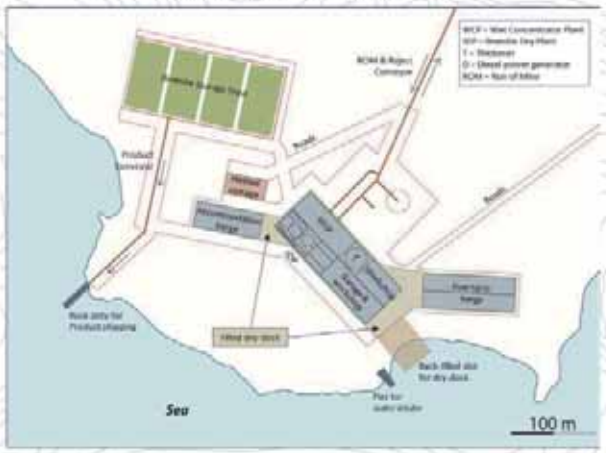
Bluejay mining plc

Dundas Titanium A/S is part of Bluejay Mining PLC corporate group.

Basic Mining & Processing



Dundas Mine Layout



Simple and proven:
- Excavation by dozer
- Easy transport by conveyor
- Simple screening
- Wet gravity plant
- Dry magnetic plant
- Bulk-carrier to market

Low environmental impact:
- Electrification
- No tailings or waste; natural products – rejected sand
- Return as back-fill in excavated open pits (90%)
- Easy mine reclamation

Planned scenario:
- Onshore mining
- All year production
- 440,000 tonnes of ilmenite concentrate per year when in full production
- 120 employees on-site

Bluejay mining plc

Bo Møller Stensgaard
Managing Director, CEO

Nunavut Impact Review Board (NIRB) and meaningful engagement

Speaker: Kaviq Kaluraq, Executive Director and Chair, Nunavut Impact Review Board

Biography: *Kaviq joined the Nunavut Impact Review Board in February 2010. Kaviq was nominated by her fellow Board members to be Chair of NIRB in 2019 - She was recently re-appointed as Chair, with a term until 2026. Kaviq lives in Baker Lake, Nunavut where she teaches in the Nunavut Teacher Education Program for Nunavut Arctic College and she speaks both English and Inuktitut.*

Karen Costello joined the NIRB in June 2020 as Executive Director where she is responsible for providing direction, leadership and ongoing management of NIRB operations and staff. She provides advice, direction and recommendations to the Board on the mandated duties of the NIRB. Prior to joining the NIRB, Karen spent over 15 years with the federal government, working in Iqaluit and Yellowknife.

Abstract: What is the Purpose of your Talk?

To introduce the Nunavut Impact Review Board as an institution of public governance that effectively engages with Indigenous Peoples and local communities to recognize and utilize traditional and western knowledge to address impacts of industry.

We will explore the different methods used to consult and participate. This includes: public hearings, interpretation support and full translations of documents, early involvement and early community sessions.

Link to *Presentation*

Arctic Mining: Environmental issues, mitigation and pollution control for marine and coastal mining

Session 3A: What can we do better on regulating the impacts of Arctic mines, and meaningfully engaging Indigenous Peoples and local communities?

March 23, 2023

Who is the NIRB

- The Nunavut Impact Review Board (NIRB or Board) is an institution of public government created by the *Nunavut Agreement* to assess the potential impacts of proposed development in the Nunavut Settlement Area prior to approval of the required project authorizations.
- Uses both traditional knowledge and recognized scientific methods to assess the biophysical and socio-economic impact of proposals and will make recommendations and decisions about which projects may proceed.
- The Board may also establish programs to monitor the impacts of projects that have been reviewed and approved to proceed.

- The NIRB, Nunavut Planning Commission, Nunavut Wildlife Management Board, and Nunavut Water Board may jointly, as a Nunavut Marine Council, or severally advise and make recommendations to other government agencies regarding the marine areas, and Government must consider such advice and recommendations in making decisions which affect marine areas.

Where we work

Participation in our work

- Tools and practices to support public participation
  - Use of social media
  - Maintain a public registry
  - Require proponents to provide translated plain language summaries
  - Community information sessions early in process
  - Interpretation support and translation of presentation material
  - Community roundtables - Women, Elders, Youth, Hunters and Trappers, Hamlet

Translated proposal by a proponent

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NIRB File No.: 16QN071

ᐱᓕᕆᔨᒃᑯᑦ ᐊᑎᖓ:	The **"Itivia Quarry"** project
ᓇᓗᓇᐃᖅᑐᑦ ᐊᑎᖓ:	Agnico Eagle Mines Ltd. (Agnico Eagle)
ᐱᓕᕆᔨᒃᑯᓕᖅ:	Quarry ᖃᐅᔨᓴᓂᖓ: Kivalliq Region
ᐊᐅᓚᓕᓴᐃᓂᖏᑦ ᖃᓄᐃᑦᑐᖓᓕᒫᑦ: www.nirb.ca	Application No.: 125046
ᐅᖃᐅᓯᓐᓄᑦ ᐃᓕᓴᕐᓇᖅ: February 17, 2017	

ᐱᓕᕆᔨᒃᑯᓕᖅ:

ᐱᓕᕆᔨᒃᑯᓕᖅ "Itivia Quarry" ᖃᐅᔨᓴᓂᖓ ᓄᓇᓕᖅ ᓇᓂᐊᕐᓇᖅ ᐅᕝᕙᓘ Kivalliq ᐅᖃᓕᓂᐅᔪᓂᒃ 500 meters ᑭᓇᐅᔭᖓ ᓄᓇᓕᖅ Rankin Inlet,ᓴᓇᔨᓂᖓ ᐱᓕᕆᔨᒃᑯᓕᖅ ᐅᕝᕙᓘ develop a quarry to support infrastructure to be established in the Itivia harbour area for the Meliadine Gold Project (NIRB File No. 11MN034). ᐱᓕᕆᔨᒃᑯᓕᖅ ᖃᐅᔨᓴᖅᑎᑦᓯᔪᓐᓇᖅ ᐅᕝᕙᓘ March ᐃᓕᓴᕐᓂᐊᕐᓂᒃ December 2017. ᐱᓕᕆᔨᒃᑯᓕᖅ ᓇᓗᓇᐃᖅᑕᐅᓚᓕᖅ ᓄᓇᓕᖅ ᖃᐅᔨᓴᖅᑎᑦᓯᔪᓐᓇᖅ ᐅᕝᕙᓘ ᐱᓕᕆᔨᒃᑯᓕᖅ:

- Extraction of quarry material using drill-and-blasting
- Transportation of diesel and emulsion for quarrying operations from the Meliadine Gold Project site
- Disposal of all waste generated at the Itivia quarry site
- Decommissioning of quarry site upon completion

ᖃᐅᔨᓴᖅᑎᑦᓯᔪᓐᓇᖅ ᖃᓄᐃᑦᑐᖓᓕᒫᑦ ᑎᑎᕋᖅᑕᐅᓚᓕᖅ ᑕᑯᓇᓗᓂᒃᑯᑦ/ ᑎᑎᕋᖅᑕᐅᓚᓕᖅ NIRB File No.: 16QN071 ᐱᓕᕆᔨᒃᑯᓕᖅ ᐃᓚᓕᖅᑎᓂᖅ, ᓄᓇᕗᑦᓂᖅ, ᐃᓄᖕᓇᐃ ᐅᖃᐅᓯᖏᑦ ᑎᑎᕋᖅᑕᐅᓚᓕᖅ.

ᐅᖃᐅᓯᖏᑦ ᑐᓴᖅᑎᑦᓯᔪᓐᓇᖅ:

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- ᖃᓄᐃᑦᑐᖓᓕᒫᑦ ᐊᓯᖏᓐᓂᖅᓴᓕᒃ ᖃᓄᖅ ᐃᓕᓴᕐᓂᐊᕐᓂᓕᒃ ᐱᓕᕆᔨᒃᑯᓕᖅᓴᓕᒃ ᐅᖃᐅᓯᖏᑦ

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Public hearing

- Sharing of community knowledge and Inuit Qaujimajatuqangit from representatives

Community reps on site visit and observing at a technical meeting

Lightning talk 3

- ***What have we learned about meaningful engagement of Indigenous Peoples and local communities in the Arctic, how does this apply to Arctic mining activities?***

Thank you

The Importance of integrating biodiversity values in mining during the earlier stages of decision-making cycle

Speaker: Elena Tracy, WWF Arctic Programme

Biography: *Dr. Tracy's research and teaching interests include the domestic and international politics of environmental protection, institutional design and environmental policies, the politics of GMOs, and other topics related to environmental governance.*

What is the Purpose of your Talk?

Mining is identified among key drivers of biodiversity loss in the Arctic region. Therefore, integrating biodiversity values during the decision-making process throughout the entire mining cycle, from pre-planning/planning, to production and decommissioning, is essential.

Abstract:

The presentation focuses on the importance of integrating biodiversity values during the earliest stages of project planning, when biodiversity-related impacts, including cumulated and wide-ranged, can be appropriately addressed and prevented. The inclusion of civil society stakeholders and Indigenous rights holders also happens at earlier phases of project planning.

WWF offers criteria for mainstreaming biodiversity into mining activities, which is particularly useful during the earliest stages of planning that allow us to prevent or significantly reduce negative impacts on biodiversity from mining as well as from associated shipping activities.

These criteria include the consideration for protected areas (eg. ArcNet), ecological corridors connecting the protected areas, as well as establishing clear processes for engaging Indigenous peoples and local communities while utilizing traditional knowledge.

Link to *Presentation*

The Importance of Integrating Biodiversity Values in Arctic Mining Projects during Early Stages of Decision-making

By Elena F. Tracy, PhD

Sustainable Development Advisor, WWF Arctic Programme, email etracy@wwf.no

Presentation delivered at the Arctic Mining Workshop, March 23, 2023

Presentation outline:

1. Key impacts and responsible mining mitigation hierarchy

2. WWF principles on responsible mining in the Arctic

3. Citronen Fjord Mining Project: crossing the red lines

4. A short criteria for a meaningful engagement with rightsholders and stakeholders

Arctic mining impacts (including coastal and marine) and mitigation hierarchy

Impacts:

- Large footprint and impacts on biodiversity
- Requires a lot of energy
- High water use
- Waste
- Pollution
- Transportation impacts from expanded infrastructure and shipping

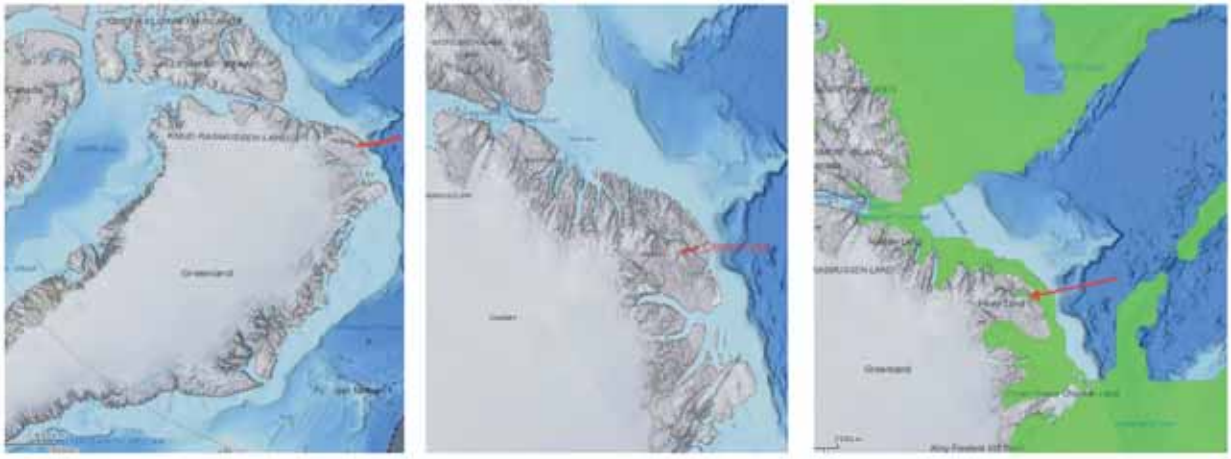
Mitigation hierarchy:

- Avoid and prevent
- Minimize
- Restore
- Offset

Some principles on responsible mining in the Arctic

- Be guided by existing best global practices established by the IUCN, ICMM and CBD
- Be tailored to the Arctic Context and informed by Indigenous, traditional and local knowledge
- Consider the full cycle of activities
- Include Red lines or No-go practices and processes that seriously threatens Arctic biodiversity:
  - ✔ *Mining in Protected Areas and Ecological Corridors*
  - ✔ *Ecological compensation and offset (last resort)*
  - ✔ *Deep seabed mining*
  - ✔ *Stranded assets (abandoned infrastructure)*

Crossing the red lines: Citronen Fjord project



Source: WWF ArcNet 1.0

The importance of incorporating biodiversity values in marine and terrestrial spatial planning (ecosystem-based management)

- Assessing negative impacts at a landscape/regional level
- ArcNet of Priority Areas for Conservation and Connectivity Corridors (including Blue Corridors) are blueprint for ecosystem based spatial marine and terrestrial planning
- Implementing circular economy to avoid mining development in Arctic ecological sensitive areas

A short criteria for meaningful consultations with rightsholders, stakeholders, and scientific community

- A non-pursuit of new mining projects and associated infrastructure that pose inacceptable risks to biodiversity **should be a real option** for consultations during the initial (pre-planning) phase to render these consultations meaningful.

- Mainstreaming biodiversity is about making appropriate, balanced and sensitive choices rather then checking boxes of consultations before processing anyway.

WWF

Session 3B) Moderated Panel Discussion - Perspectives across sectors on mining regulation, impact and management - What has been learned? What are the best practices to balance future mining activities with protection of the Arctic environment?

Strategic Environmental Impact Assessment – A Greenland example on how to inform a planning process

Speakers: Janne Fritt-Rasmussen, Aarhus University

Biography: *Janne Fritt-Rasmussen, Ph.D., is an environmental engineer with >10 years of experience in Arctic research, project management and teaching at university level. Since 2012 she has been working with consultancy regarding the environmental aspects of oil exploitation in Greenland, at the DCE - Danish Centre for Environment and Energy, Aarhus University.*

What is the Purpose of your Talk?

The purpose of this talk is to introduce the concept of strategic environmental impact assessments and its potential as a tool in an environmentally sound planning and regulation of mining activities.

What is the relevant background and context?

As an aid to obtain a regional overview of nature and environmental conditions, the Greenland Environmental Agency for Mineral Resources Activities, has commissioned the preparation of Regional Environmental Baseline Assessments (RBA) of mining activities. The Assessments are being developed by DCE and GINR.

What do we need to know about methodology and actors?

Knowledge of nature and the environment is needed to be able to plan and regulate raw material activities. For most marine, and selected land areas in Greenland, the latest knowledge is gathered in regional environmental assessments and background study reports. They describe the physical and biological environment, including protected areas, endangered species, and the exploitation of biological resources. Local knowledge is an important part of the assessments.

The environmental assessments also include a description of background levels for pollutants and possible local sources of pollution.

Based on this knowledge of the current situation, areas of multiple interest are identified, and the general potential environmental impact of raw material activities is discussed and assessed. The draft RBAs are going into public hearings and can inform the decision process.

What are the key learning points you want to share?

As an important part of the regional environmental assessments, significant deficiencies and uncertainties in the available knowledge are identified, and research projects are

carried out to obtain supplementary data. These background studies have made it possible to provide an overall mapping of particularly sensitive nature areas such as bird colonies, moulting areas for diving ducks, concentration areas for marine mammals and coastal spawning areas for fish. The regional environmental assessments thus provide an overview of the latest knowledge about nature and the environment for a given area based on research and local knowledge, and the data can be used in many contexts.

What are the next steps raised by your talk and/or questions that need to be answered?

How can we further ease how locals and other stakeholders contribute to the environmental assessments?

How can we improve our methodology to further ease the access to nature and environmental information to inform public discussions and make it easier for both industry and authorities to plan mining activities wisely?

Link to *Presentation*

STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

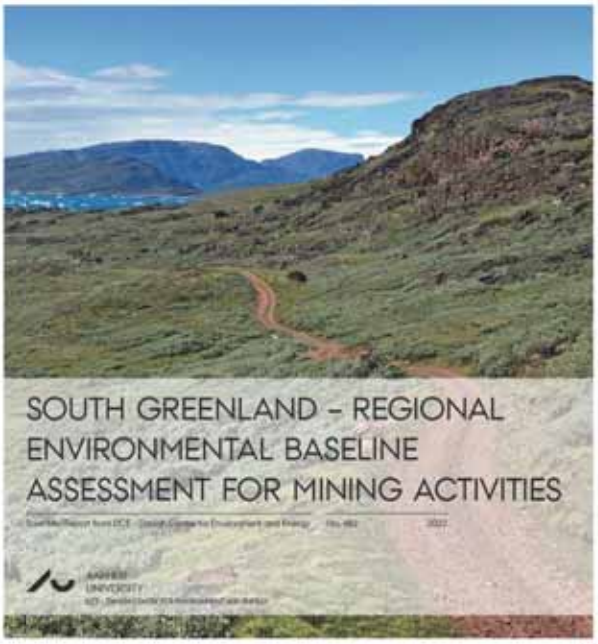
- A GREENLAND EXAMPLE ON HOW TO INFORM A PLANNING PROCESS

Special consultant, PhD Janne Fritt-Rasmussen, jfr@ecos.au.dk

Arctic Mining Workshop - March 21-23, 2023 - Session 3B

PURPOSE OF TALK

Introduce the concept of *strategic environmental impact assessments and regional environmental baseline assessments* as a potential tool in an environmentally sound planning and regulation of mining activities.



AARHUS UNIVERSITY DEPARTMENT OF ECOSCIENCE
ARCTIC MINING WORKSHOP MARCH 21-23, 2023 | JANNE FRITT-RASMUSSEN SPECIAL CONSULTANT

BACKGROUND

As an aid to obtain a regional overview of nature and environmental conditions The Greenland Environmental Agency for Mineral Resources Activities, has commissioned the preparation of *Strategic Environmental Impact Assessments and Regional Environmental Baseline Assessments*.

The Assessments are being developed by DCE and GINR.

https://ecos.au.dk/en/researchconsultancy/themes/regional-background-studies

CONTENT OF A SEIA/RBA

- Compiling available data in a report re. geological information, vegetation, important biological areas, environmental chemistry, human use, archeological important areas etc.
- Knowledge of the location of vulnerable and important areas through studies of the distribution of plant and animal species as well as local knowledge.
- Field campaigns for sampling and updating knowledge base.
- Improved public access to updated environmentally relevant knowledge and data

https://rba.eamra.gl/
https://augis.au.dk/portal/apps/webappviewer/index.html?id=aad3dfc90e38470f963bac94377fa189#
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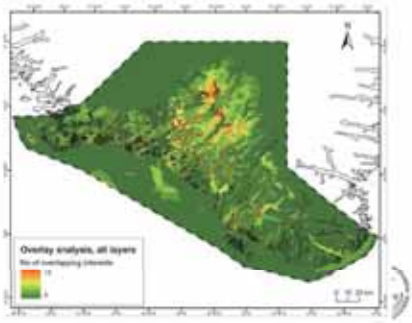
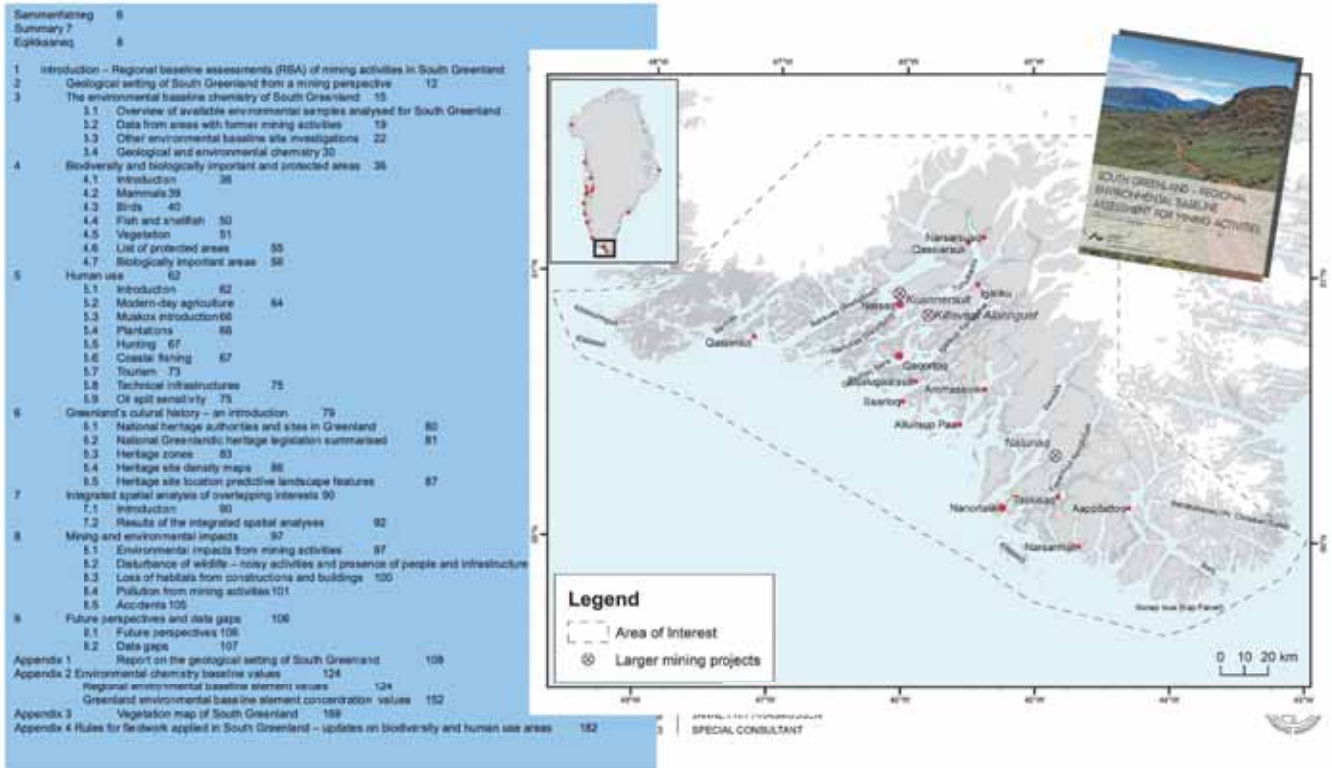
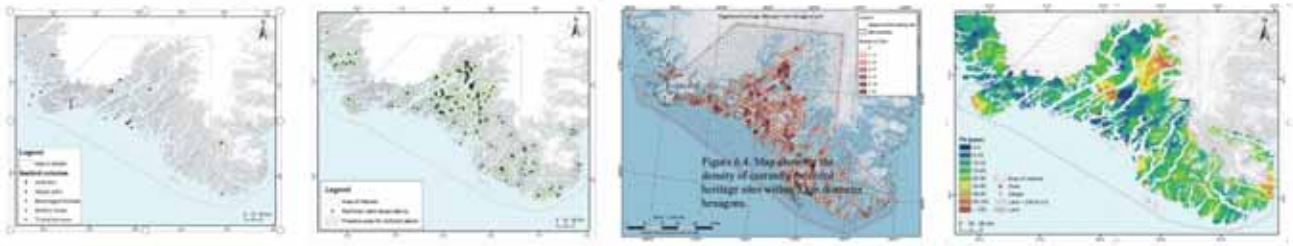




KEY LEARNING POINTS

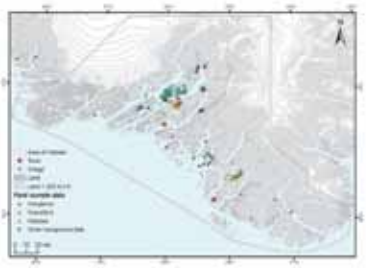
- Knowledge gaps
- Research projects to obtain supplementary data

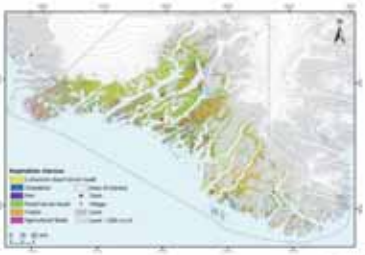


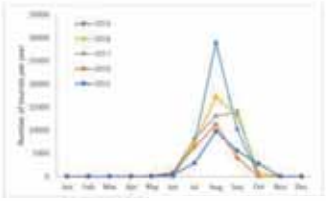
The regional environmental assessments thus provide an overview of the latest knowledge about nature and the environment for a given area based on research and local knowledge, and the data can be used in many contexts.

THE USE OF RBA/SEIA IN PLANNING

- To make it easier for the authorities to plan and regulate mining activities in relation to nature and the environment.
- To make it easier for locals and other stakeholders to get information on the potential impact of mining activities in the region.
- To make it easier and less costly for companies and their consultants to plan exploration activities considering the environment.







FUTURE FOCUS - NEXT STEPS

- Ease how locals and other stakeholders contribute to the environmental assessments
- Improve our methodology to further ease the access to nature and environmental information to inform public discussions and make it easier for both industry and authorities to plan mining activities wisely

https://ecos.au.dk/en/researchconsultancy/themes/videospots-greenland/

Thank
you!

Moderated Panel Discussion:

Perspectives across sectors on mining regulation, impact and management - What has been learned? What are the best practices to balance future mining activities with protection of the Arctic environment?

Panel Speaker 1: Alex Buchan, Agnico Eagle Director of Nunavut Affairs, Stakeholder Engagement

Biography: *Alex Buchan is an Inuk residing in Cambridge Bay, Nunavut with a background in wildlife management and community economic development with previous work experience at the municipal and territorial government levels. He is an active marine mammal and fish harvester. He has been actively supporting Hope Bay gold mine development for over 15 years, and is now the Agnico Eagle Director of Nunavut Affairs, as well as representing the company as Vice President (Nunavut) on the NWT/Nunavut Chamber of Mines."*

Abstract:

It is possible to discover, explore, permit, construct and operate a modern mine in Canada's Nunavut territory without significant adverse effects on the marine environment.

Agnico Eagle Mines Ltd. is the largest mine operator in the Nunavut territory of Canada, with 3 operating areas that have existed for 14, 13 and 6 years respectively.

Agnico Eagle makes use of the marine environment to conduct an annual commodity and equipment resupply, and for discharging tested and treated mine effluent. Agnico Eagle Nunavut operations have been subject to Canadian Mining and Marine Transportation regulation, Nunavut co-management environmental assessment and licensing, and Inuit Owned Land Management practices. Annual reporting under this regime demonstrates that no significant adverse environmental impacts have been experienced within this level of development.

Existing Nunavut marine environmental management could be considered a best practice among similar jurisdictions.

Link to *Presentation*

Arctic Mining Virtual Workshop

Arctic Mining:
Environmental Issues, Mitigation and Pollution Control for Marine and Coastal Mining

Alex Buchan, Director, Nunavut Affairs

AGNICO EAGLE

SLIDE SUMMARY

1. **Agnico Eagle Overview**
2. **Nunavut Marine Regulatory Overview**
3. **Agnico Eagle Marine Environmental Management Performance**

UNIQUE GROWTH STORY

AGNICO EAGLE

- Over **65 years** in business
- Employs more than **16,000** people worldwide
- **11** operating mines in **4** countries
- Largest gold producer in Canada and **3rd** worldwide

We are the largest miner in Nunavut territory

Nunavut Properties

AGNICO EAGLE

We currently have three operations in Nunavut: the Meliadine and Amaruq mines, along with our Meadowbank mining complex, in Nunavut's Kivalliq region, as well as our Hope Bay project, in Nunavut's Kitikmeot region.

- Each mine employs 1000+ people
- Currently over 500 Inuit Employees

NUNAVUT HISTORY TIMELINE

AGNICO EAGLE

AGNICO EAGLE IN NUNAVUT

2007	2010	2013	2017	2019	2021	2022	Next phases
Meadowbank Acquisition (Cumberland)	Meadowbank Commercial Production	Amaruq Discovery Hole	Amaruq and Meliadine Announced for Construction	Amaruq and Meliadine Commercial Production	TMAC Acquisition	Amaruq Underground Commercial Production	Meliadine Extension
	Meliadine Acquisition (Comaplex)				Amaruq Underground Announced for Construction		Meadowbank Life of Mine Extension ?
							Hope Bay Project Execution ?

16 Years of experience managing marine environmental effects in Nunavut

Common Categories of Marine Impact

- **Marine Transport (annual re-supply)**
- **In Water Works (docks/jetties)**
- **Mine Effluent Discharge (including saline mine water)**

Most significant marine risk is identified as the transport and offloading of diesel fuel from Tankers.

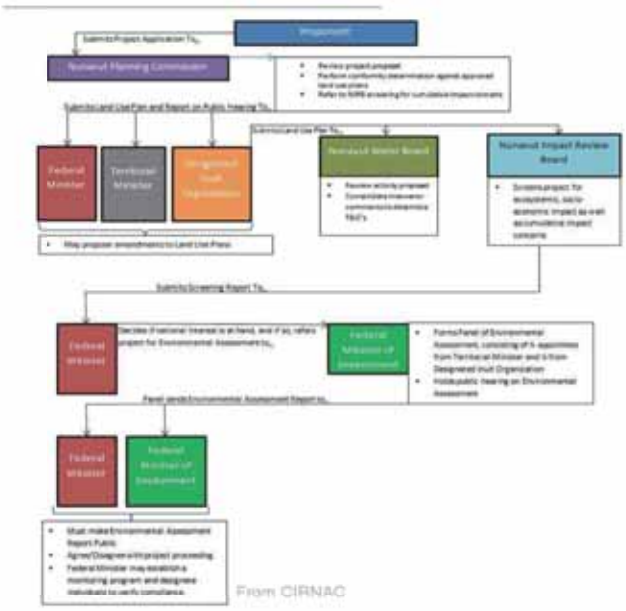
NUNAVUT MARINE REGULATORY FRAMEWORK

AGNICO EAGLE

Canada Shipping Act	• Provides an overall regime to protect safety and the environment for vessels operating in Canadian jurisdiction – waters out to the 200 nautical mile limit. • Its regulations include requirements for a vessel's construction, how it manages ballast water, its pollution control equipment, arrangements for emergency response, and its crew qualifications.
Arctic Waters Pollution Prevention Act	• Provides enhanced protection for vessels operating in Canadian jurisdiction north of 60°north latitude. • Provides specific construction standards for vessels engaged in Arctic shipping, a system of shipping safety control zones, a ban on discharges of oil, hazardous chemicals, and garbage, and requirements for vessels to carry insurance to cover damages from any these discharges.
Marine Liability Act	• Sets out a regime that requires vessels operating in Canadian jurisdiction to carry insurance to pay for damages from oil spills.
Fisheries Act - Metal and Diamond Mining Effluent Regulations	• Sets out a regime that requires that mine effluent discharged to the aquatic environment cannot be deleterious, must meet discharge water quality criteria, and pass an acute lethal toxicity test on several aquatic species.
Fisheries Act - Authorizations Concerning Fish and Fish Habitat Protection Regulations	• Sets out a regime that requires that in water works must be approved, that impacts to fish and fish habitat be assessed, and any decrease in overall fish habitat be offset or compensated for.

Agnico Eagle has successfully complied with all applicable marine environmental regulations since beginning mine development in Nunavut in 2007

NUNAVUT SPECIFIC CO-MANAGED ENVIRONMENTAL ASSESSMENT PROCESS



From CIRNAC

In addition to Laws of General Application, Nunavut environmental management involves regulatory process that guarantee equal participation by Inuit in *Institutions of Public Government*

- Nunavut Planning Commission **("NPC")** (Land Use Planning) – 2 Agnico Eagle operations comply with existing Land Use Plan for their operating area, NLUP draft pending
- Nunavut Impact Review Board **("NIRB")** (Impact Assessment) – All Agnico Eagle operations have undergone NIRB Review, and operate under NIRB Project Certificates
- Nunavut Water Board **("NWB")** (freshwater use) – All Agnico Eagle operations have undergone NWB licence application process and operate under NWB Licences in good standing

AGNICO EAGLE MARINE ENVIRONMENTAL PERFORMANCE

Metric	Meadowbank	Meliadine	Hope Bay
Project Certificate Terms and Conditions ("TC") total	68	131	54
Marine TCs	7	18	7
Further commitments	0	0	86
Marine further commitments	0	0	10
TC Summary	Shipping Management Plan required including engagement, monitoring and regulation of ship movements.	Shipping Management Plan required, spill prevention, management of saline discharge into ocean.	Shipping Management Plan required, avoiding marine bird colonies, reporting ship strikes, management of saline discharge into ocean.
NIRB Monitoring Report Marine mentions (2021)	Lack of Marine Monitors (Covid related)	Reporting of any bird strikes of supply ships needs to be clarified.	Cumulative impacts study with other projects needs to begin.

NIRB public monitoring of Agnico Eagle Marine Environmental Performance

- ~10% of total terms and conditions and commitments
- Demonstrated attention by NIRB of potential marine environmental effects
- Requirement for Shipping Management Plans a common feature
- Additional effluent discharge requirements over and above *Metal and Diamond Mine Effluent Regulations*
- Agnico Eagle in significant compliance with some, mainly Covid related, slippage

CONCLUSION

AGNICO EAGLE

Agnico Eagle has a 16-year history of;

a) Designing, building, and operating mines in Arctic Canada in full compliance with national marine laws regarding our annual sealift

b) Successfully undertaking public Nunavut environmental assessments during which marine Valued Ecosystem Components ("VECs") are considered

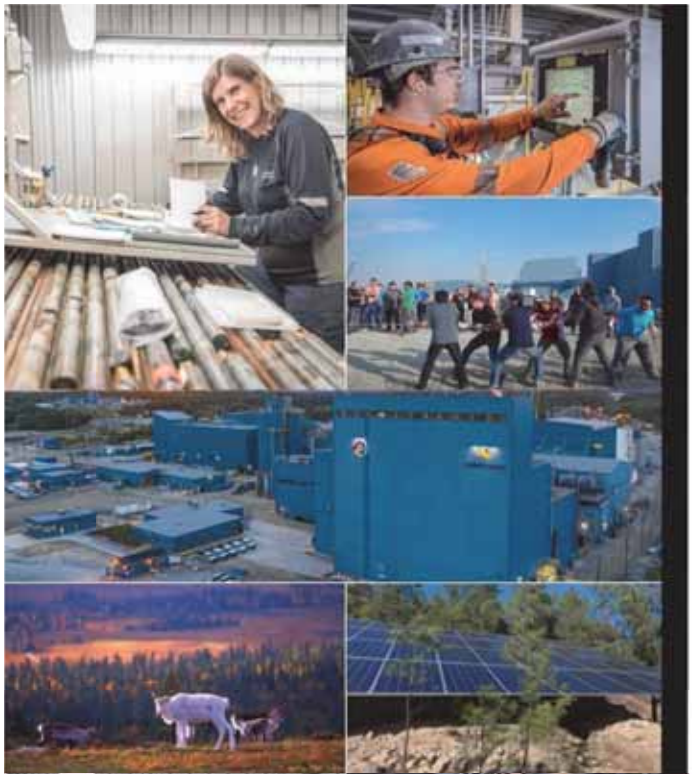
c) Successfully addressing NIRB Marine Project Certificate terms and conditions (including voluntary commitments)

Agnico Eagle also has a 3-year history of discharging mine effluent into the ocean with no significant adverse environmental effects

The existing Canadian and Nunavut regulatory and Inuit co-management framework is capable of mitigating impacts of mining on marine environments

Agnico Eagle commitment to achieve 30% reduction in carbon emissions by 2030, and to become carbon neutral by 2050 which will reduce/eliminate risks associated with transporting and offloading diesel fuel in Arctic waters.

Agnico Eagle maintains a robust community relations function that continually identifies and responds to public concerns and questions, including those about the marine environment



Thank You

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Quanaqutin

Trading Symbol:
AEM on TSX & NYSE

Investor Relations:
416-847-8665
info@agnicoeagle.com

agnicoeagle.com

WORLD GOLD COUNCIL

AGNICO EAGLE

Panel Speaker 2: Steen Christensen, Environmental Agency for Mineral Resource Activities, Government of Greenland

Biography: *Since December 2019, Dr. Christensen has been based in Nuuk working with the Government of Greenland. From December 2019 - October 2021 as the Chief Advisor with the Ministry of Fisheries, Hunting and Agriculture. And since November 2021 as Head of the Environment Agency for Mineral Resource Activities (EAMRA).*

Abstract

The presentation presents a brief overview of the evolution of the mining industry in Greenland from the first cryolite mine opening in Ivittuut in 1854 to the opening of the zinc-led mine Maarmorilik in the 1970s where the first environmental studies on effects of mine site activities were conducted.

Recognizing that the old mine sites might be potential sources for pollution, environmental studies were initiated in the early 1970s. The research and continued monitoring at these polluted sites have enabled studies on the effects of mining pollution under Arctic conditions and provided a solid knowledge platform for sustainable development of the mining industry in Greenland under the guidance of the Environmental Agency for Mineral Resource Activities.

The presentation highlights some of the extreme climatic and logistic conditions that the mining industry faces in Greenland and emphasizes the conditional Environmental Impact Assessment that is designed to evaluate and mitigate the potential risks to the sensitive arctic environment.

To continue the sustainable development of the mining industry in Greenland the presentation highlights the need for stronger community engagement, application of best available practice (BAP), best available technologies (BET), and promoting reduction of emissions and use of renewable energy.

Link to *Presentation*

The Environmental Agency for Mineral Resources (EAMRA)
March 2023

NAALAKKERSUISUT
GOVERNMENT OF GREENLAND

Towards sustainable mining and a greener Greenland

Digging up the past to pave the future

Steen Christensen, Head of Agency

NAALAKKERSUISUT
GOVERNMENT OF GREENLAND

The Environmental Agency for Mineral Resource Activities (EAMRA)

- **EAMRA** is the administrative authority on all aspects concerning environment, nature, and climate in connection to mineral resource activities in Greenland.
- **EAMRA** is advised by scientific, independent advisors from:
  - ✔ **DCE** – Danish Centre for Environment and Energy.
  - ✔ **GINR** – Greenland Institute of Natural Resources.
  - ✔ **GEUS** – Geological Survey of Denmark and Greenland

Mining history in Greenland

General challenges in the Arctic

- Remoteness and accessibility
- Limited knowledge prior to mining.
- Short time-window for activities

Physical challenges in the Arctic

NAALAKKERSUISUT
GOVERNMENT OF GREENLAND

- Harsh climate.
- Seasonal fluctuations.
- Limited infrastructure.

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GOVERNMENT OF GREENLAND

Challenges in the Arctic – land use and biology

- Low species diversity.
- Hot spots.
- Short food chains with key species.
- Many unknowns.
- Living resources dependency.
- Disturbance sensitivity - human activties.
- Multiple land use interests.
- Cumulative effects.
- Climate change.

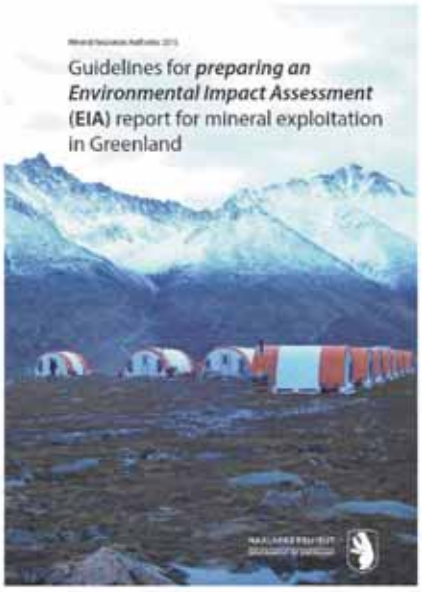
Environmental Impact Assessment (EIA) in Greenland

Activities and processes

- Impacts, mitigation and alternatives

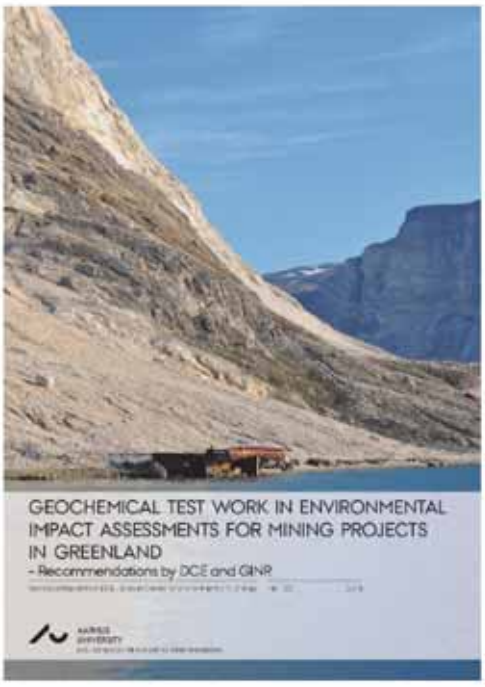
All mining phases:

- Baseline
- Pre-mining
- Operational phase
- Closure
- Post-closure



Environmental Impact Assessment challenges

- Pre-mining baseline conditions.
- Technical documentation.
- Alternative analyses.
- Closure and post-closure phase.
- Predicted effects.
- Quantification of environmental effects.



Future perspectives

Increased focus on:

- Cumulative effects.
- Climate change □ temporal variations.
- Dialogue and community engagement
- Implementation of greener solutions.
- BAT + BEP.

Panel Speaker 3: Jared Ottenhof, Qikiqtani Inuit Association*

Biography: *Jared began working in Northern Canada with the Kitikmeot Inuit Association, living in Kugluktuk, representing the organization for impact assessments and other regulatory work, then moved to Nunavut Tunngavik Incorporated in Rankin Inlet as an Environmental Resource Management Advisor, and currently works as Director of Lands and Resource Management for the Qikiqtani Inuit Association in Iqaluit, NU.*

Abstract:

I provided a short summary of the functioning purpose of the Qikiqtani Inuit Association, and other similar regional organizations, and the role they play in relation to Industry. Currently, the QIA is the recipient group of several Inuit Impact Benefit Agreements, and are able to provide feedback on projects (such as the Mary River Project) as they continue to be reviewed by governing bodies.

*Denotes Oral presentation given without visual tools.

Panel Speaker 4: Lis Bach, Aarhus University

Biography: *Lis Bach is a Senior advisor at DCE, Aarhus University. Marine ecology and ecotoxicology. She is a researcher on fate and effects of contaminants in the marine environment, and provides advisory tasks to the environmental authorities on environmental issues related to mining industries.*

Abstract:

Mining in the Arctic holds special precautions. The environment is more fragile to disturbances than in other parts of the world and climate conditions need special attention.

Although mining activities are expected to increase, there are still few active mines in the Arctic.

Arctic mining is expanding into greener mining with focus on lower environmental impacts.

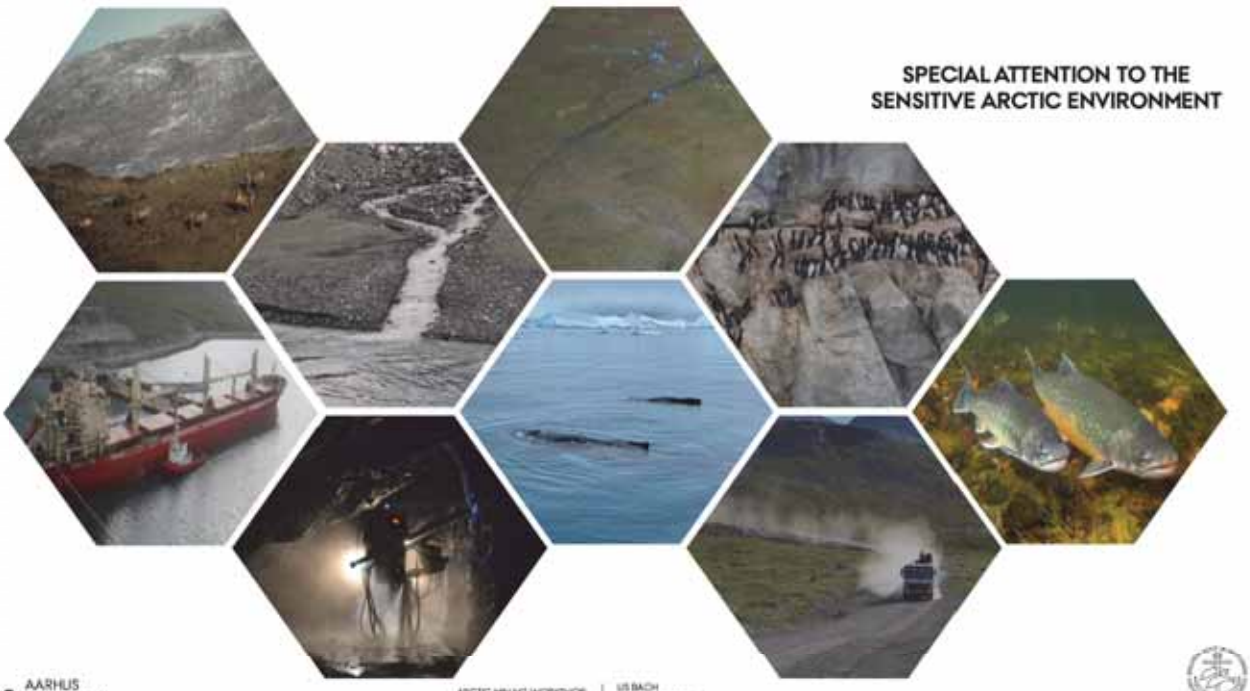
To promote such a process there is a need for more research under Arctic conditions to support both technology and regulation and increased collaboration between researchers and industries could pave the way.

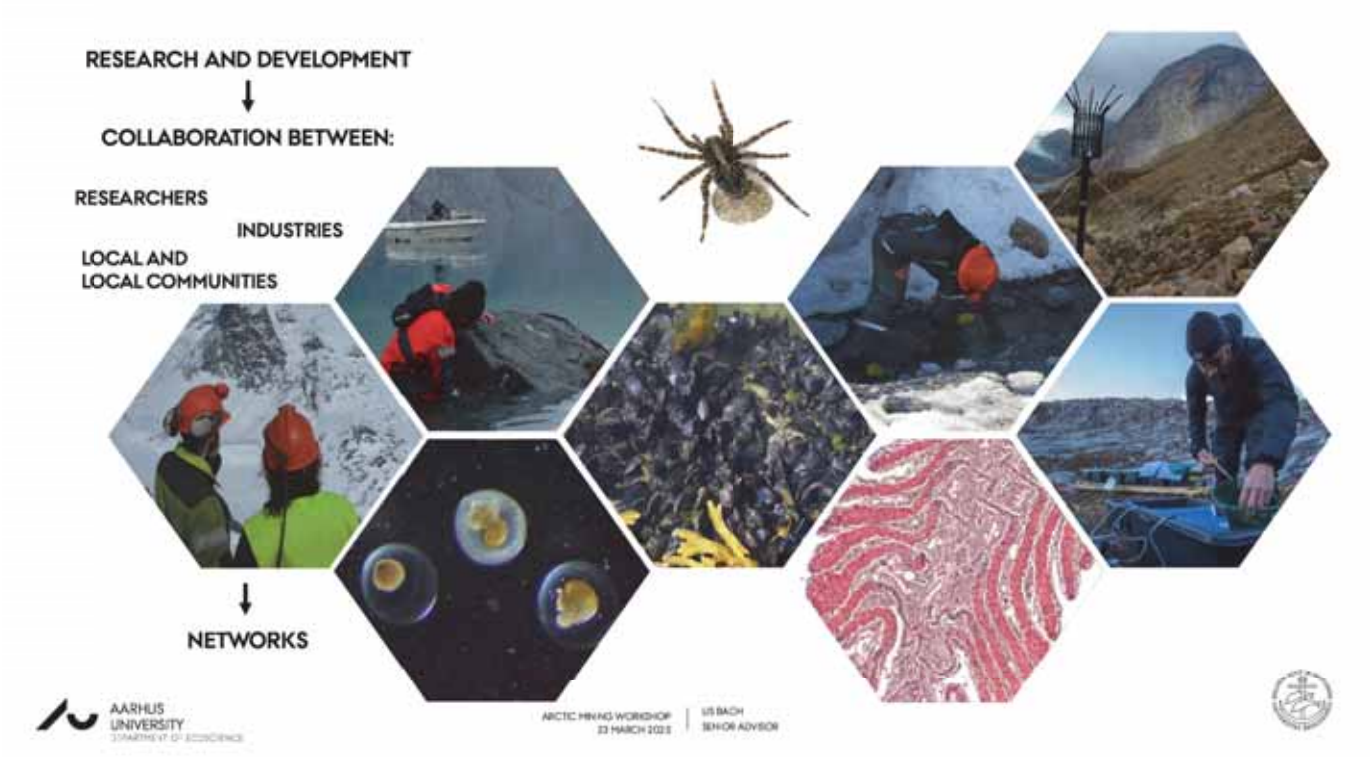
Link to *Presentation*

A POINT OF VIEW FROM A SCIENTIST

LIS BACH, PhD, SENIOR ADVISOR
Ecology and Ecotoxicology
AARHUS UNIVERSITY

SPECIAL ATTENTION TO THE SENSITIVE ARCTIC ENVIRONMENT





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