Greenland Last Ice Area

Potentials for hydrocarbon and mineral resources activities

Mette Frost, WWF-DK Copenhagen, September 2014
Report
Greenland Last Ice Area. Potentials for hydrocarbon and mineral resources activities.
The report is written by Mette Frost, WWF Verdensnaturfonden.

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WWF Verdensnaturfonden, Svanevej 12, 2400 København NV. Denmark.
Phone +45 3536 3635 – E-mail: wwf@wwf.dk

WWF Global Arctic Programme, 275 Slater Street, Ottawa, Ontario, K1P 5L4. Canada.
Phone: +1 613 232 2535

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Other WWF reports on Greenland – Last Ice Area
Greenland Last Ice Area. Scoping study: socioeconomic and socio-cultural use of the Greenland
LIA. By Pelle Tejsner, consultant and PhD. and Mette Frost, WWF-DK. November 2012.

Seals in Greenland – an important component of culture and economy. By Eva Garde, WWF-DK. November 2013.

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Yellow house in Kullorsuaq, Qaasuitsup Kommunia, Greenland. July 2012. Mette Frost, WWF
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The report can be downloaded from
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Last Ice Area Introduction

This is one of a series of research resources commissioned by WWF to help inform future management of the Area we call the Last Ice Area. The title refers to the area of summer sea ice in the Arctic that is projected to last. As climate change eats away at the rest of the Arctic’s summer sea ice, climate and ice modellers believe that the ice will remain above Canada’s High Arctic Islands and above Northern Greenland for many more decades.

Much life has evolved together with the ice. Creatures from tiny single celled organisms to seals and walrus, polar bears and whales, depend to some extent on the presence of ice. This means the areas where sea ice remains may become very important for ice-adapted life in future. One of my colleagues suggested we should have called the project the Lasting Ice Area. I agree, although it’s a bit late to change the name now, that name better conveys what we want to talk about. While much is changing, and is likely to change around the Arctic, this is the place that is likely to change the least. That is also meaningful for the people who live around the fringes of this area – while people in other parts of the Arctic may be forced to change and adapt as summer sea ice shrinks, the people around the LIA may not have to change as much.

As a conservation organization, WWF is not opposed to change. Our goal is to help maintain important parts of the natural world, parts that are intrinsically and extrinsically important to the wellbeing of humans and animals. WWF does not hold the power nor the authority to impose its vision on people. Instead, we try to present evidence through research and options for action. It is then up to the relevant authorities as to whether they will take action or not; the communities, the Inuit organizations and the governments of the Last Ice Area will decide its future fate. We hope you will find the information in these reports useful, and that it will help you in making wise decisions about the future of the Last Ice Area.

Clive Tesar, WWF Global Arctic Programme. Last Ice Area project lead.
Last Ice Area / Sikuusarfiit Nunngutaat

Siunissami Last Ice Area-mik (LIA) taagugaq – imaluunniit Siku Kingulleq pillugu misissuinissap nakikutigineqarnissaanut ikorfartuiniarluni misissuinerit ilaattut misissuineq una WWF-ip aallartippaa. Issittup imartaa aasaanerani sikuuinnartartoq, sivisunerpaamik aannikuungnitsoq misissuinerup taaguuteqaatigaa. Issittup imartaa aasaanerani sikuuinnartartoq silap pissusaata allangngoriartornera peqqutigalugu milliartuinnaraluartoq, sikumik silallu pissusaata allangngoriartornieranik misissuinerit naapertorlugit, qeqertat Canadaav unanallaat kanganittut kiisalu Kalaallit Nunaata avannaata avataata suli ukiuni quilikkaani arlalinni sikuuinnarallassapput.


Clive Tesar, WWF Global Arctic Programme. Projektleder Last Ice Area.
Dette studie er et i en række af studier, som WWF har igangsat med det formål at bistå fremtidige forvaltninger af det område, som vi kalder Last Ice Area / Den Sidste Is. Navnet refererer til det område med sommerhavis i Arktis, som beregnes til at bestå længst. I takt med at klimaforandringerne tærer på den resterende sommerhavis i Arktis, forudser is- og klimaberegninger, at denne is fortsat vil eksistere over Canadas nordøstlige øer og over Nordgrønland i mange århier endnu.

Meget liv har udviklet sig sammen med isen. Fra de mindste encellede organismer til sæler, hvalrosser, isbjørne og hvaler er en hel række skabninger afhængige af tilstedeværelsen af denne is. I fremtiden kan de områder, hvor der stadig findes havis, blive meget vigtige for de dyr, der er tilpasset et liv ved isen. En af mine kolleger foreslog, at vi skulle have kaldt området Lasting Ice Area /Den Blivende Is. Selvom det er for sent at ændre navnet nu, så giver jeg ham ret i at denne titel bedre ville formidle det vi ønsker at tale om. Mens meget er under forandring og sandsynligvis vil ændre sig i Arktis, er dette område det, der formentlig vil ændre sig mindst. Det har også stor betydning for de mennesker, der bor i udkanten af dette område. Mens folk i andre områder af Arktis kan blive tvunget til at ændre og tilpasse sig, i takt med at sommerhavisen får en mindre udbredelse, behøver de mennesker, der lever ved Last Ice Area måske ikke at ændre deres livsform helt så meget.

WWF er en natur- og miljøbeskyttelsesorganisation der ikke modsætter sig al forandring. Vi arbejder for at beskytte og bevare natur, og især den natur der er vigtig simpelthen fordi den findes og fordi den er vigtig for mennesker der. WWF har hverken indflydelse eller mandat til at pålægge andre vores vision. I stedet forsøger vi at dokumentere vores holdninger gennem forskning og ved at fremlægge handlingsmuligheder. Det er heretter op til de relevante myndigheder om de vil handle eller ej: lokalsamfund, organisationerne og regeringerne i det område, hvor vi finder Last Ice Area/Den Sidste Is, vil afgøre områdets fremtidige skæbne. Vi håber, at I vil finde rapporten nyttig, og at den vil hjælpe til med at træffe gode beslutninger om fremtiden for Last Ice Area/Den Sidste Is.

Clive Tesar, WWF Global Arctic Programme. Projektleder Last Ice Area.
Summary

Human presence in the Greenland LIA has always been closely linked to the living resources of the marine environments. Historically, researchers have established a link between Northern Canada and Greenland based on immigration and harvest. It is believed that ecological hot spots like the North Water polynya in northern Baffin Bay may have been an important driver for immigration (Heide-Jørgensen et al, 2013). In the northern Greenland community of Qaanaaq harvesting natural resources is still a way of life.

But the living resources are not the only resources of the Greenland LIA, and local hunters and fishermen are no longer the only people who use the Greenland LIA and harvest the resources found here. With this report we establish an overview of the mineral and hydrocarbon resources found within the Greenland LIA and we discuss scenarios for future development.

Modern debates about mineral resources and development in Greenland often leave one with the impression that mining is a new industry here. But commercial mining dates back to 1856. Over the last 150 years Greenland has undergone dramatic changes – and some of these changes have been linked to or even initiated by mining. The 1972 closure of the Qullissat coal mine led to widespread protests and these protests, along with other protests, formed into the first political movements in Greenland. New political voices argued the need to bring decision making to Greenland and this process formed first the Greenland Home Rule (1979-2009) and the Greenland Self-Government (2009 - ).

With the 2009 Act on Greenland Self-Government and the 2010 Mineral Resources Act, jurisdiction over mineral and hydrocarbon resources found in the soil and sea bed of Greenland rests with the Greenland Government. But this transfer of jurisdiction from Copenhagen to Nuuk has added new complexities to the relationship between Greenland and the Kingdom of Denmark. Two recent examples are discussed in the report; the decision to allow for mining of uranium and other radioactive minerals in Greenland that left open the question of whether Greenland can export its uranium, and the development in hydrocarbon resource activities that allows for a discussion about protection of the marine environment and resources for clean-up in the event of a large oil spill or leak.

The licensing process is governed by the Mineral Resources Act and guidelines established by the Greenland Government. Central to the licensing process are the environmental impact assessments (EIA) and social impact assessments (SIA) that are prepared by the licensee and made available for public discussion in a consultation. The consultation processes have been contested by environmental NGO’s and local groups, who have argued that there is a need for earlier involvement in the process, more information, and more dialogue before decisions on licensing are made.
The mineral resources of the Greenland LIA

The coastal region of North Greenland is prospective for a wide range of base metals, including iron, copper, zinc and lead. Most exploration activities are targeting base metals, but occurrences of silver, gold, titanium, vanadium, barite, wolfram and rare earth elements are also found along with silicon dioxide and aluminum dioxide.

Currently the only mature project within the Greenland LIA is the Citronen Fjord /Ironbark Zinc Ltd. project targeting one of the world’s largest resources of zinc and lead. The company believes the resources are economically feasible to mine even if initial capital costs exceed USD 420 million and even if operations will be challenged by harsh weather conditions, sea ice etc. Preparation for the application process started in 2012 and the Greenland Government has announced that an application is expected in 2014 (Greenland Government, 2013). Annual production is estimated to be 250,000 tons of zinc concentrate and 30,000 tons of lead concentration per annum. The mine is expected to have a lifetime of 14 years and to return revenue of USD 5.65 billion/ DKK 31 billion (Ironbark Zinc Ltd. 2013).

In Greenland mineral resources activities are currently subject to a 30 pct. corporate tax on revenues that would generate an income of DKK 10 billion over the lifetime of the Citronenfjord mine, not including income taxes and other indirect taxes from the mining activities. Political discussion about corporate revenues led the 2013 coalition of Siumut, Atassut and Partii Inuit to promise the electorate that royalties on mineral resources will be introduced (Siumut, Atassut og Partii Inuit, 2013).

For construction 1,000 workers are needed, but most likely these will be foreigners as there are few unemployed construction workers available in Greenland. A permanent staff of up to 300 miners will be needed in the mine, but as no communities are found in the region the mine must be operated on a fly-in fly-out schedule with miners living in barracks. In Greenland, citizens are subject to a 37 pct. income tax covering local and national taxes.

Other prospecting of mineral resources in the Greenland LIA is at an early stage and it is difficult to assess if these resources will be developed into mineable reserves. Mines will be developed where companies and investors expect a positive return on their investments.

Costs associated with mining in Greenland involve costs of establishing infrastructure needed in often remote areas as well as costs associated with taxes and royalties and costs for impact assessments and mitigation of negative environmental and social impacts. This may be subject to negotiations with the Greenland Government. Looking at the potential income, investments are guided by world market prices and in particular by future world marked demand and supply for particular resources. With the information available it is not possible to establish the entry price for a potential mining project, but we can speculate that growing demand and/or reduced supply of zinc will make the investment in the Citronenfjord project more likely.
The oil and gas resources of the Greenland LIA

The U.S. Geological Survey estimates that 22 pct. of the world’s undiscovered, technically recoverable oil, natural gas and natural gas liquids are found within the Arctic region (USGS, 2008). Of the 412 billion of oil equivalents (BOE)\(^1\) estimated for the Arctic region, 11 pct. is estimated to be found within the Greenlandic territory.

Based on USGS estimates for the three provinces relevant to the Greenland LIA; the West Greenland - East Canada Province (17 million BOE), the East Greenland Rift Basins Province (31 million BOE) and the North Greenland Sheared Margin (3 million BOE), potential future development in the region is discussed.

The Greenland LIA core area – the coastal region of North Greenland – is prospective for oil and gas but the resource is relatively small and the region is still a frontier difficult to assess. The Last Ice Area is an area of projected persistent summer sea ice (at least over the next few decades) and exploration activities will continue to be challenged by the presence of sea ice. Exploration activities today are focused on resources outside the Greenland LIA, primarily offshore West Greenland. But the interest of oil exploration companies have moved from south to north along the coast of West Greenland and large investments are made in the Baffin Bay region, which is well south of the Last Ice Area but near vulnerable and important ecosystems, e.g. Melville Bay and North Water Polynya, whose services are important to wildlife and humans in the region. The large resources estimated for the East Greenland Rift Basins Province are less accessible and the challenge of the pack ice, moving from north to south along the East Greenland coast, is a challenge for activities here.

Greenland Government in a draft oil- and gas strategy for 2014-2018 (Greenland Government, 2013), introduces open door procedures for areas covering onshore Jameson Land, East Greenland, and off shore Southwest Greenland in 2014 and new license rounds for oil and gas activities onshore in the Disco-Nuussuaq region in West Greenland and in Baffin Bay north of 71°N in 2016 and 2017. In 2018 a new license round for offshore Davis Strait (63°N - 67°N), West Greenland, is expected. The Greenland Government through this strategy commits to a long-term goal of continued exploration for commercial values of oil and gas and to have between five and ten mines in operation.

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\(^1\) BOE: ‘A term used to summarize the amount of energy that is equivalent to the amount of energy found in a barrel of crude oil. There are 42 gallons (approximately 159 liters) in one barrel of oil, which will contain approximately 5.8 million British Thermal Units (MBtus) or 1,700 kilowatt hours (kWh)’ (definition from Investopedia).
WWF-DK assesses that we will see exploitation of oil and gas resources in the Baffin Bay region, but that the Greenland Sea region will remain a frontier to be developed. Drilling for oil and gas in the core Greenland Last Ice Area by 2040 is unlikely.

In the light of mineral and hydrocarbon resources activities there is a need for new governance. This need is evident where current interests and uses overlap, as illustrated by layering information about wildlife abundance and traditional uses with information about exploration activities. In two areas there are currently overlapping interests; the Melville Bay region, where seismic activities in 2012 and 2013 did overlap with narwhal habitat, and in the Kane Basin/Inglefield Land where licenses overlap with polar bear habitat.

Informed by research and knowledge about current uses and projection for future uses, governance should be developed to secure sustainable development of the Greenland LIA. While there are still gaps in data, observations by local users have documented areas that are valuable and sensitive for single species and entire ecosystems. To sustain these vulnerable and sensitive areas management plans should be established. Informed by projections for climate change and impacts of these changes on wildlife, management plans should also include scenarios for changed uses of the area. For the Greenland LIA, changes in use are likely to be driven primarily by exploitation of the mineral and hydrocarbon resources of the region.

This report helps inform a parallel analysis prepared by an independent consultant assessing the current and future development of minerals and hydrocarbon resources in the Canadian and Greenlandic sections of the Last Ice Area. The joint analysis will establish scenarios for mineral and hydrocarbon resources activities across the Last Ice Area based on known reserve estimates, the likely costs of developing those reserves, and projections of demand for those resources. Such an analysis will help establish the likely economic viability of extractive industry developments in the LIA.

Recommendations

WWF recommends that Greenland embarks on a sustainable development path that balances the development of new industry, in particular of mineral resources and oil and gas resources development, with other uses.

WWF recommends the Greenland Government to commit to long-term governance and management plans informed by research in climate change and the effects that climate change will have on Arctic ecosystems, and informed by knowledge about current uses and projects for future uses of the natural resources of Northern Greenland.

More specifically, WWF recommends that the Greenland Government:
• Develop a strategy for the **National Park of North and East Greenland**, building from existing research and knowledge about ecologically and culturally important areas as well as scenarios for climate change.

• Consider new management measures that will secure adaptive management of **resilient summer sea ice between** North Greenland and the Canadian Archipelago. This resilient summer sea ice will become an important habitat for ice-dependent species.

• Develop management measures to protect and conserve the **North Water Polynya**, an open water area acknowledged for its importance to marine mammals and sea birds in the region.

• Consider the introduction of zoning – a flexible management mechanism that protects a core area from human disturbances but allows for some uses in buffer zones and for development outside these zones - in management. Zoning could be introduced in renewed management of **Melville Bay/ Qimussersiarsuaq** and in management of **Inglefield Land/Kane Basin**.
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- **Pikialasorsuaq (North Water Polynya),** tassaasoq imartaq sikuneq ajortoq nunap immikkoortuani tassani miluumasunut timmissanullu imarmiunut pingaaruteqarni pillugu ilisimaneequarlartuoq pillugu mianerinninnissaq piujuauannartitsisassalru siunertaralugit aqutsinissamik periusissanik ineriartortitseqqullugit.

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Sammenfatning

Menneskets tilstedeværelse i de sidste islægsområder (LIA) i Grønland har altid været nært forbundet med de levende ressourcer i det marine miljø. Set i et historisk perspektiv har man fra videnskabelige verden kunnet etablere en forbindelse mellem det nordlige Canada og Grønland baseret på immigration og udnyttelse af ressourcer. Det formodes at de økologiske brændpunkter som Pikialasorsuaq (North Water Polynya) i den nordlige del af Baffin Bugten kan have udgjort en tilskyndelse til immigration (Heide-Jørgensen et al., 2013). I den nordligste grønlandske by Qaanaaq udgør udnyttelsen af de levende ressourcer stadig den dag i dag en betydelig del af den daglige levevis.

Imidlertid udgør de levende ressourcer ikke de eneste ressourcer i de sidste islægsområder i Grønland, og de stedlige fangere og fiskere er ikke længere de eneste brugere af de sidste islægsområder i Grønland og de eneste, som høster ressourcerne fra den natur som findes her. Med denne rapport opstiller vi en oversigt over de mineralske og fossile ressourcer, som findes inden for de grønlandske islægsområder og vi gør rede for de forskellige scenarier for en fremtidig udvikling.


Processen omkring udstedelse af licenser styres gennem Råstofloven og retningslinjerne fastsættes af Naalakkersuisut. I forbindelse med udstedelse af licenser spiller rapporterne vedr.
vurderingen af de miljømæssige påvirkninger (EIA) og vurderingen af de sociale påvirkninger (SIA), som udarbejdes af den licensøgende og siden bliver offentliggjort med henblik på en offentlig debat, en central rolle. Høringsprocesserne er blevet udfordret af NGO'er såsom miljøorganisationer og lokale grupper, som har argumenteret for nødvendigheden af en tidligere medvirken i processen, mere information og mere dialog før beslutninger om licenstildelinger træffes.

**De mineralske ressourcer i Last Ice Area**

Kystregionen i Nordgrønland indeholder potentialer på en lang række grundlæggende metaller, heriblandt jern, kobber, zink og bly. De fleste forundersøgelsesprojekter baserer sig på grundmetallerne, men forekomster af sølv, guld, titanium, barium, wolfram og sjældne jordarter er også blevet observeret på linje med siliciumdioxid og aluminiumdioxid.

For tiden er det eneste færdigudviklede projekt inden for det grønlandske islægsområde Citronen Fjord/Ironbark Zink Ldt. projektet, som sigter på én af verdens største forekomster af zink og bly. Selskabet tror på at ressourcerne er tilstrækkeligt økonomisk rentable til at starte udvinding, selv om de basale omkostninger vil overstige USD 420 mio. og skønt bestræbelserne vil blive udfordret af barske vejrforhold, hvis m.v. Forberedelserne til ansøgningsprocessen startede i 2012 og Naalakkersuisut har meddelt, at en ansøgning påregnes modtaget i 2014 (Grønlands Selvstyre, 2013). Den årlige produktion beregnes at være på 250.000 tons zinkkoncentrat og 30.000 tons blykoncentrat. Minen forventes at have en levetid på 14 år og at kunne generere et overskud på USD 5.65 mia. / DK 31 mia. (Ironbark Zinc Ldt. 2013).

I Grønland er den nuværende selskabsskat på mineralske råstoffaktiviteter fastsat til 30%, hvilket vil kunne indbringe en indtægt på kr. 10 mia. i Citronen Fjord-minens levetid, her uden at medregne skatter og andre indirekte skatter fra mineaktiviteter. Politiske diskussioner omkring selskabsskatter ledte den i 2013 etablerede koalition bestående af Siumut, Atassut og Partii INUIT til at love vælgerne, at man ville indføre royalties på mineindustrien (Siumut, Atassut og Partii Inuit, 2013).

Til anlæggelsen vil der være behov for 1.000 arbejdere, men højst sandsynligt vil arbejdssstyrken bestå af udefrakommende arbejdskraft, eftersom der kun er få ubeskæftigede bygningsarbejdere til rådighed i Grønland. I selve minen vil der være behov for en permanent arbejdssstyrke på op til 300 mennesker, men da der imidlertid ikke eksisterer beboede steder i denne region må minen betjenes af personale, som flyves ind og flyves ud, og som må bo i barakker under opholdene. I Grønland er borgerne pålagt en indkomstskat på 37%, opdelt på lokalt og på nationalt plan.

Andre råstoffprojekter i Grønlands sidste islægsområde befinder sig stadig på et forberedende stade og det er vanskeligt at forudsige, om de pågældende ressourcer eventuelt vil kunne udvikles til levedygtige minevirksomheder. Minerne vil blive placeret de steder hvor selskaberne og investorerne forventer et positivt udbytte af deres investeringer.

Olie- og gasforekomsterne i Last Ice Area


Baseret på USGS' beregninger for de tre regioner af betydning for det grønlandske islægsområde; Vestgrønland - det østlige Canada, Rift Basins provinsen i Østgrønland (31 million BOE) og det nordgrønlandske spillerum (3 million BOE), er potentielle fremtidige udviklingsprojekter til stadighed under diskussion.

De vigtigste områder i Grønland - kystregionerne og Nordgrønland - er prospektive for olie- og gasressourcer, men ressourcerne er relativt få og lave og regionen er stadig vanskeligt tilgængelig. Islægsområderne udgør de områder hvor man forudser stadige forekomster af is i havet om sommeren (i det mindste gennem de næste få år) og efterforskningsaktiviteter vil fortsat være udfordret af isens tilstedeværelse. Efterforskningsaktiviteter, der finder sted i dag er centreret på ressourcer placeret uden for de grønlandske islægsområder, og primært i det vestlige Grønland.

Men interessen hos de selskaber som ønsker at udvinde olie er flyttet fra det sydlige Grønland langs kysten til den nordlige del af Vestgrønland, og store investeringer foretages i områderne ved Baffin Bugten, som ligger noget sydligere end islægsområderne, men alligevel tæt på sårbare og betydningsfulde økosystemer, fx. Melvillebugten og Pikialasorsuaq (North Water Polynya), hvor udbyttet fra havmiljøet er vigtigt for dyrelivet og menneskene i regionen. De store forekomster der formodes at ligge på den østgrønlandske Rift Basins Province er vanskeligt tilgængelige og udfordringerne fra pakisen, som bevæger sig fra nord mod syd på den grønlandske østkyst er en udfordring for aktiviteter i disse egne.

Naalakkersuisut har fremlagt en olie- og gasstrategi for perioden 2014-2018 (Grønlands Selvstyre, 2013), hvor man introducerer den åbne dørs procedure for de områder, der dækker Jameson Land i Østgrønland og i havet omkring det sydvestlige Grønland i 2014 og nye licensrunder for olie-

I 2018 vil en ny licensrunde for offshore Davisstrædet (63°N-67°N) i Vestgrønland kunne forventes. Naalakkersuisut binder sig gennem denne strategi til en langsigtet målsætning om en fortsat efterforskning efter kommercielt bæredygtige værdier af olie og gas og til at kunne få opstartet fem til ti miner i funktion.

WWF-DK anslår at vi vil se udnyttelse af olie- og gasressourcer i Baffin Bugt regionen, men at det grønlandske havområde stadig vil udgøre et grænseområde til udvikling. Boringer efter olie og gas i de sidste centrale grønlandske islægsmråder omkring 2040 må anses som usandsynligt.

I lyset af aktiviteterne omkring mineralske råstoffer og fossile ressourcer er der opstået et behov for en ny styringsstruktur. Dette behov er tydeligt hvor interesserne og brugen trænger ind på hinanden. Det kan illustreres ved at lagde oplysninger om dyrelivets rigdom og den traditionelle brug oven på oplysninger om efterforskningsaktiviteter.

I to regioner er der i øjeblikket overlappende interesser; Melville Bugt-regionen, hvor seismiske aktiviteter i 2012 og i 2013 blev foretaget trods en stedlige narhvalsbestand, og i Kane Basin/Inglefield Land, hvor licenserne - overlapper - overlapper levestederne for isbjørne.

Gennem viden og gennem forskning om den aktuelle brug og udsigterne for den fremtidige brug bør styringsstrukturen udvikles for at sikre en bæredygtig udvikling af de sidste grønlandske islægsmråder. Mens der stadig eksisterer huller i de eksisterende data har observationerne fra de lokale fangere påvist områder som er vigtige og sårbare for enkelte dyrearter og for hele det spredte økosystem.


Denne rapport skal medvirke til at yde en parallel analyse, udarbejdet af en uafhængig konsulent som har vurderet den gældende og den fremtidige udvikling af mineralske og fossile ressourcer i de sidste canadiske og grønlandske islægsmråder. En fælles analyse vil etablere scenarier for aktiviteter relateret til mineral- og fossilaktiviteter tværs over islægsmråderne baseret på kendte beregninger af reserverne, de sandsynlige omkostninger ved udviklingen af de pågældende ressourcer samt udsigterne for efterspørgslen af disse ressourcer. En sådan analyse vil hjælpe til med at etablere den sandsynlige finansielle levedygtighed af udvindingsindustrielle tiltag inden for de sidste arktiske islægsmråder.
Anbefalinger

WWF anbefaler at Grønland forfølger et udviklingsspør, som skaber balance i udviklingen af nye industrier, og i særdeleshed industrier relateret til udviklingen af de mineralske og fossile ressourcer, sammen med andre brugsmetoder.

WWF anbefaler over for Naalakkersuisut at man forpligter sig til en langsigtet ledelses- og styringsplan baseret på forskning omkring klimaforandringerne og de konsekvenser som forandringerne vil have på det arktiske økosystem, samt baseret på viden om aktuelle projekter og en fremtidig anvendelse af naturressourcerne i det nordlige Grønland.

Mere specifikt anbefaler WWF Naalakkersuisut, at:

- Udarbejde en strategi for Nationalparken for Nord- og Østgrønland, baseret på den eksisterende forskning og viden om økologisk og kulturelt vigtige områder såvel som scenarier for klimatiske ændringer.

- Overveje nye forvaltningsskemener som kan sikre en tilpasningsdygtig styring af det fleksible sommerislæg mellem Nordgrønland og det canadiske øhav. Dette fleksible sommerislæg vil udgøre et vigtigt levested for de arter, der er afhængige af havisen.

- Udvikle forvaltningsplaner for at beskytte og bevare Pikialasorsuaq (the North Water Polynya), et åbentvandsområde anerkendt for dets betydning for områdets havpattedyr og søfugle.

1. Introduction – scenarios for resources development within the Greenland LIA

The purpose of this study is to establish an overview of mineral and hydrocarbon resources within the Greenland Last Ice Area (from now Greenland LIA). The study will help inform future scenarios for the Greenland LIA based on known resources, potential resources activities and the consequences of these activities for nature, wildlife and communities within the Greenland LIA.

This introductory section gives a first overview of the resources of the Greenland LIA and an introduction to the geological characteristics of the Greenland LIA. Many readers may be surprised to find that geological research and commercial mining dates back to the 1800’s in Greenland. In section 2 the current debates about mineral resource development in Greenland is put into a historical setting and we experience how mining has influenced local communities but also the relationship between Greenland and Denmark. Eight cases are used to describe the many potential consequences – negative as well as positive – which mining may have for a country. Governance aspects of mineral and hydrocarbon resources development are discussed in section 3. Section 4 establishes an overview of mineral resources found in the Greenland LIA, prospecting, exploration and exploitation activities taking place and ends with a discussion about the future scenarios for developing mining in the Greenland LIA. Section 5 follows the same structure with an overview of hydrocarbon resources, activities, and a discussion about future scenarios. This is followed by a discussion focusing on the need for comprehensive management plans taking into account the sometimes overlapping interests and uses of the Greenland LIA.

1.1 Last Ice Area

WWF has worked since 2011 on researching, discussing and bringing forward future management options for the projected area of resilient summer sea ice.

In September 2012 the National Snow and Ice Detection Centre documented the lowest seasonal extent of sea ice since the first satellite images of the Arctic were produced in 1979. With a minimum extent for the year of 3.41 million square kilometres it reinforced the long-term downward trend in Arctic sea ice extent. The average minimum extent for 1979-2000 was 6.70 million square kilometres. A comparison between the 2012 and 1984 satellite images gives an idea of to what extent conditions in 2012 strayed from the long-term average; 1984 was close to the 30 year average of 6.70 million square kilometres, the 2012 minimum extent was only 3.41 million square kilometres, almost half the average extent. The September 2012 minimum extent was well below the previous record of 4.17 million square kilometres in 2007 (NASA Earth Observatory, online).
Sea ice models project that in 2040 a fringe of sea ice will remain in Northeast Canada and Northern Greenland when all other large areas of summer sea ice have disappeared. The remaining area of summer sea ice constitutes a potential critical habitat for ice dependent species, and therefore WWF has set out to study the future for this area and to bring ideas for management options to the table. This is the Last Ice Area

![Image](image.png)

**Figure 1** Projected sea ice extent, September 2040. WWF Global Arctic Programme.

The Greenland LIA study area includes the Greenland/Denmark territory north of the 76°N latitude, covering marine regions, coastal areas and sections of the Greenland Ice Sheet.

The geographical extent of the Last Ice Area encompasses the Kane Basin and Ellesmere Island as the westernmost boundaries and includes the town of Qaanaaq (pop. 678) and the US Air Force Base at Thule/ Pituffik, alongside the smaller constituent settlements; Savissivik (pop. 58), Qeqertat (pop. 28), and Siorapaluk (pop. 56).

In Northern Greenland the LIA area includes the remote coast Peary Land, Cape Morris Jessup and the northernmost land of Inuit Qeqertaat/ Kaffeklubben Ø. Geological surveys have documented resources of minerals (zinc and iron ore) as well as petroleum potentials onshore; the Franklinian Basin, North Greenland (80 - 83°N) and off shore North-East Greenland Shelf (75 - 80°N) (Henriksen, *et al*, 2000).

In Northeast Greenland the LIA area encompasses the ice sheet, coastal and marine regions of Kronprins Christian Land and Germania Land. The former is home to Station Nord and the latter to Danmarkshavn, both facilities of the Danish Royal Navy. Aarhus University, Denmark, and the Villum Foundation announced in spring 2013 that Station Nord will be developed into a modern
high-arctic research facility in the coming years. This station will supplement research stations in Zackenberg, East Greenland, Nuuk Basic, West Greenland, and Arktisk Station Qeqertarsuaq, West Greenland.

Resources of the Greenland LIA

Human presence in the Greenland LIA has always been closely linked to the living resources of the marine environment. Historically researchers have established a link between Northern Canada and Greenland based on immigration and harvest. It is believed that ecological hot spots like the North Water polynya in northern Baffin Bay may have been an important driver for immigration (Heide-Jørgensen et al, 2013).

Harvest of wildlife is still an important part of everyday life in Qaanaaq. As discussed in a report about the socio-economic and socio-cultural uses of the Greenland LIA (WWF-DK, 2013), subsistence hunters harvest narwhal, beluga, walrus and polar bear while harvest of seal, caribou and birds and eggs is conducted by both subsistence and non-subsistence hunters. Hunters in the Qaanaaq district take pride in the fact that they are providing most of West Greenland with mattaq from narwhals.

But new opportunities are developing. The area experiences increasing stocks of Greenland Halibut and investments are made to improve the small facility for trade in, handling and storage of fish and meat in Qaanaaq. Adaptation to climate change may well mean more fishing and less hunting in the Qaanaaq district but this transition may take years or even generations as most of the 40 subsistence hunters in Qaanaaq identify closely with hunting. Knowledge and skills as well as equipment are passed on from father to son and along with this the identity of a hunter.

But the living resources are not the only resources of the Greenland LIA, and local hunters and fishermen are no longer the only people who use the Greenland LIA and harvest the resources found here. With this report we will establish an overview of mineral and hydrocarbon resources found in the Greenland LIA and discuss scenarios for developing these non-living resources into new industry.

1.2 Geology of the Greenland LIA

Greenland’s geology is an extension of the geology of North America and Northern Europe. Archaean cratons hold potentials for diamonds, gold and rare earth elements, Palaeoproterozoic mobile belts with potentials for base metals like iron, lead, zinc, nickel and copper, platinum group elements (PGE), gold and tantalum, Lower Paleozoic sediments with potentials for base metals, Carboniferous Cretaceous sediments with potentials for coal, and Lower Tertiary intrusive
complexes, the Skýrgaard intrusion being the most important in terms of gold and platinum group elements (PGE).

The geology of the sea bed has large sedimentary basins that are highly prospective for petroleum.

**The geological characteristics of the Greenland LIA**

The Geological Survey of Denmark and Greenland (GEUS) has published comprehensive information about the geology of Greenland on its website and in a wide range of publications. The below introduction to the geological development of Greenland, which will form the basis of the discussion about the mineral and hydrocarbon resources of Greenland, is building on Geological map of Greenland 1: 2,500,000 (GEUS).

The geology of Greenland preserves nearly four billion years of Earth history – from the earliest Archaean to the Quaternary. The central basement shield is composed of gneiss complexes and belts of metamorphosed sedimentary and volcanic rocks that came into existence during episodes of mountain building 3,800 to 1,600 million years ago.

Greenland is dominated by crystalline rocks of the Precambrian shield, formed during a succession of Archaean and early Proterozoic orogenic events which stabilized as a part of the Laurentian shield about 1,600 million years ago. The Laurentian shield can be divided into three basement provinces: Archaean rocks 3,100 to 2,600 million years old with local older units, Archaean terranes reworked during the early Proterozoic around 1,850 million years ago and terranes mainly composed of juvenile early Proterozoic rocks, 2,000 – 1,750 million years old. Subsequent geological developments mainly took place along the margins of the shield.

During the later Proterozoic and throughout the Phanerozoic major sedimentary basins formed, notably in North and North-East Greenland, and in places accumulated sedimentary successions reached 10 – 15 km in thickness. Palaeozoic orogenic belts, the Ellesmerian fold belt of North Greenland, and the East Greenland Caledonides affected parts of these successions.

Upper Palaeozoic and Mesozoic sedimentary basins developed along the continent–ocean margins in North, East and West Greenland and are now preserved both onshore and offshore. Their development was closely related to continental break-up with formation of rift basins. Initial rifting in East Greenland in latest Devonian to earliest Carboniferous time and succeeding phases culminated with the opening of the North Atlantic in the late Paleocene. Sea-floor spreading was accompanied by extrusion of Tertiary plateau basalts in both central West and central East Greenland.
During the Quaternary Greenland was almost completely covered by ice sheets, and the present inland ice is a relic of the Pleistocene ice ages. Vast amounts of glacially eroded detritus were deposited on the coastal shelves offshore Greenland.

The western parts of the Greenland LIA is characterized by a variety of sedimentary and volcanic basins, mostly gneisses formed in the Archaean reworked in early Proterozoic (colours orange and yellow). To the north Inglefield Land is dominated by gneisses 2,000 to 2,200 million years old (colour pink).

**Figure 2** Geological map of Greenland, 1: 2 500 000 (Geological Survey of Denmark and Greenland). Map no. 5.
The ice free areas of North Greenland are part of the Franklinian Basin which reaches from Ellesmere Island, Canada, into Washington Land, Nansen Land and Pearly Land (colours green). The darker green areas are part of the North Greenland Fold Belt and lighter shades of green are sediments from the Cambrium – Silur period.

Figure 3 Geological map of Greenland, 1: 2 500 000 (Geological Survey of Denmark and Greenland). Map no. 8.
North East Greenland is dominated by the East Greenland Caledonian Fold Belt and offshore sedimentary basins.

Figure 4 Geological map of Greenland, 1: 2 500 000 (Geological Survey of Denmark and Greenland). Map no. 11.

In 2002 GEUS prepared a compilation of digital topographic maps and data on geology, biology and archeology as part of the ongoing efforts to establish a strategy for the National Park of North and East Greenland. Maps and reports are available on the GEUS website (Geological Survey of Greenland and Denmark, online).
1.3 Climate change

The Arctic is increasingly emerging as a region at the forefront of global climate change. According to the Intergovernmental Panel on Climate Change “[M]ultiple lines of evidence support very substantial Arctic warming since the mid-20th century.” Looking ahead, the same report says “[T]he Arctic region will warm more rapidly than the global mean...” and, “It is very likely that the Arctic sea ice cover will continue to shrink and thin and that Northern Hemisphere spring snow cover will decrease during the 21st century as global mean surface temperature rises.” (IPCC Fifth Assessment Report, 2013).

Climate change has been dramatic in the Arctic. Warming has been at least twice as fast as the global average (Arctic Council and the International Arctic Science Committee, 2005). And the Arctic Monitoring and Assessment Programme (AMAP) in its report on Snow, Water, Ice and Permafrost in the Arctic (AMAP, 2011) makes the following projection for 2080:

- Average Arctic autumn-winter temperatures are projected to increase by 3 to 6°C by 2080 even using scenarios in which greenhouse gas emissions are projected to be lower than they have been for the past decade

Arctic summer sea ice is shrinking at a rate of 11 pct. per decade and the Arctic Monitoring and Assessment Program’s SWIPA report states that, ‘a nearly ice free summer is now considered likely for the Arctic Ocean by mid-century’. As the ice shrinks, the open Arctic ocean absorbs more heat from the sun, reinforcing the melting process (Sommerkorn, M. and Hassol, S. J. eds., 2009).

A reduction in the overall presence of sea ice is very likely to have dramatic consequences not only for Arctic wildlife such as polar bears and ice-dwelling seals who depend upon the ice for rearing their young but also for coastal communities who rely on local wildlife for nutritional and cultural benefits. At the same time, sea ice reduction in Arctic waters is likely to increase shipping and marine access to the region’s resources while consequently increasing the likelihood of environmental damage that can harm marine life and the health of local populations (Arctic Council, Arctic Marine Shipping Assessment, 2009).

Climate change is dramatically influencing northern communities. In Greenland, the government has put adaptation to climate change on the agenda in order to understand the changes ahead and plan for a climate-changed future. The consequences of warming of the oceans and changes in aquatic life is of particular concern to Greenlanders, as the country is highly dependent on fishing for northern shrimp, Greenland halibut and Arctic cod. In a study of climate change in fisheries and hunting, the government identified and discussed measures for climate change adaptation (Grønlands Selvstyre, 2012).

Climate change may improve the prospects for some mineral resources activities. Near Maarmorilik in West Greenland, Angle Mining A/S has plans to re-open the old Black Angel mine. Studying
glacier retreat in the area with the use of aerial photography, they estimated that since 1954 glaciers near the mine have retreated by 850 meters. In the last decade alone glacial retreat is estimated at 250 meters. Angle Mining A/S plans to first mine pillars from the old site, estimated at five years of operation, and then shift activities to nearby discoveries which have been uncovered by receding glaciers, adding another 15 years to operations (Metals World, 2013), (Worldcrunch, 2012).

Other aspects of climate change affecting mining activities are related to sea ice cover as mining operations depend on access to shipping routes. For one potential mine, the Citronen Fjord lead and zinc project in North Greenland, the shipping window is currently only six weeks a year with the assistance of icebreakers. Intensive shipping in these six weeks is planned, but retreating sea ice may result in a wider shipping window increasing the feasibility of the project (Ironbark Gold, 2011).
2. Mining in a historical setting

Research into Greenland’s geology and resources has a long history. In the early 1800s German actor, playwright and mineralogist Karl Ludwig Giesecke became one of the first to work systematically with Greenland’s mineralogy. In 1801 he wrote a comprehensive manuscript on the classification of minerals.

In 1805 he obtained approval from the Danish King Christian VII to explore the geology of the Faroe Islands and Greenland. He visited the Faroe Islands in 1805 and in 1806 he travelled to Greenland. There he learned to use the local *Umiaq* – an open boat made with skin – allowing him to explore large sections of the south and west Greenland coastline. Giesecke’s journey laid the foundation for Greenlandic mineralogy, but met many difficulties including harsh winters. The Napoleonic wars forced him to stay in Greenland for seven years as the Danish fleet had been reduced in war. Giesecke’s collection of 872 mineral samples included rare minerals like cryolite, arfvedsonite and eudialyte. Following Giesecke’s journey, a research tradition of the study of minerals rapidly developed in Denmark and Greenland and this influenced the studies of the geology of Greenland.

Today more than 500 minerals from Greenland have been registered; a significant proportion of the world’s 4,000 known minerals. Many formations have helped researchers to obtain a better understanding of geological processes and identifying possible deposits of mineral resources (GEUS, 2008).

Known mineral deposits contain gold, the platinum group elements, molybdenum, nickel, the specialty metal tantalum and niobium (in the mineral pyrochlore) as well as several forms of industrial minerals. Industrial minerals are a large group of mineral resources which can be used without particular refining. This may include minerals for the construction sector, for casting and grinding, as well as minerals used as fillers for the paper and dyeing industry. Exploitation efforts may also lead to new finds of diamonds – the largest diamond found so far of 2.39 carats was reported in 2006 – as well as exploitation of known deposits of rubies near Qeqertarsuatsiaat, West Greenland.

2.1 Experiences with mining in Greenland

The current debate on mineral resources development in Greenland often leaves one with the impression that mining is a new industry in Greenland. But commercial mining has taken place since the 1850’s with the exception of 1990 to 2004, where no mines were in operation in Greenland.
Long before commercial mining was established Inuit were knowledgeable about some mineral resources. Archeologists and ethnographers have documented how Inuit made knives, harpoons and other tools with iron from the Cape York meteorite found near Savissivik within the Greenland LIA (Huntington, 2002). The settlement Savissivik, which rests on Meteorite Islands, tells the story as the Greenlandic name translates into ‘the place where iron / knives can be found’.

The history of commercial mining in Greenland allows us to travel back some 150 years in time. Greenland has undergone dramatic change since then, and some of these changes have been linked to commercial mining. When in 1972 the decision was made to close the Qullissat coal mine, and with it a town of 1.400 inhabitants, protests developed and formed into the first Greenlandic political parties. New political voices argued the need to bring decision making back to Greenland and the process that led to the establishment of Greenland Home Rule (1979-2009) was started.

Positive impacts are often associated with jobs and incomes generated from mining. One example is Uummannaq, where incomes and tax revenues generated from the Black Angel mine were invested into infrastructure and in loan schemes to develop more jobs in fisheries.

Below, eight examples of commercial mining in Greenland are discussed. The cases are the Ivittuut cryolite mine (1856-1987), the Qullissat coal mine (1924-1972), Mestersvig lead and zinc mine (1956-1963), Maarmorilik marble mine (1936-1940 and 1966-1971), Black Angel mine (1972-1990), Kvanefjeld uranium research activities (1958-1981), the Nalunaq gold mine (2004-2008 and 2009 – 2013) and the Seqi olivine mine (2005-2009). Even when not operating the mines remain relevant for a number of reasons: plans to re-open abandoned mines; tailings remain a source of pollution at some sites; and the debate about building a culturally, economically, and environmentally sustainable future for Greenland.
Case 1; the Ivittuut cryolite mine (1856-1987)

Building on Giesecke’s research, mining of cryolite ore took place from 1856 – 1987 near Ivittuut, South Greenland. A concession was first given to Kryolith Mine & Handelselskabet, and cryolite was shipped to Denmark and North America for processing.

In Copenhagen the first cryolite factory was established in 1859, but demand was limited even if researchers established how cryolite could be used in aluminum production. However, with WWI and WWII the world saw a dramatic increase in demand for aluminum and the strategic importance of cryolite resources was clear. From 1920 Ivittuut cryolite was important for US production of air planes, and in the years leading up to WWII annual export peaked at 40,000 tons. 1/3 of the cryolite mined was exported to the US.

The Ivittuut cryolite mine was in the early years seen as isolated from the rest of Greenland. The mine was operated by Kryolitselskabet Øresund a/s, a Danish cooperation owned partly by the Danish state. Cryolite ore as well as profits were taken out of Greenland and no Inuit were employed in the mine. But this dramatically changed when Denmark was occupied in 1940 and Kryolitselskabet Øresund a/s was unable to continue the operation of the mine from Copenhagen. Four weeks after the occupation it was announced that all management of the mine now rested with landsfogederne/ Governors of Greenland Eske Brun and Aksel Svane. A Greenlandic mining board was established to continue operation of the mine. In the light of the war cryolite was of strategic importance and high demand from USA and Canada led to the production peak in 1942 when 85,000 tons of cryolite were exported (Heinrich, 2012). Incomes generated from the Ivittuut mine were used to sustain the Greenland society.

Over the years a total of 3.7 million tons of cryolite was mined in Ivittuut. Activities ended in 1987 when the last shipment of cryolite ore left Ivittuut.

Today some of the old facilities are still found and the abandoned open pit mine is flooded with sea water. Since 1982 the area has been monitored by the Danish Center for Environment and Energy (DCE) (formerly the National Environmental Research Institute NERI/DMU) when elevated levels of zinc (Zn) and lead (Pb) were first documented in the Arsuk Fjord.
In 2004, researchers documented elevated levels of lead in brown seaweed (*Fucus vesiculosus*) on a 7 km stretch of the coastline in eastern Arsuk Fjord and zinc levels were elevated on most of the coastline studied in Arsuk Fjord. In blue mussels (*Mytilus edulis*) elevated levels of lead were seen in all of the studied parts of the Arsuk fjord and on coasts 3-4 km outside the fjord. As a result, harvest of mussels is not recommended along a 10 km coastline around Ivittuut. Elevated levels of zinc and lead are not found in fish and shellfish and therefore no restrictions on fisheries in the Arsuk Fjord apply.

A recent report shows that levels of lead have continued to decrease (Johansen et al, 2008). Comparing samples from 1982 with samples from 2007, researchers found that levels of lead in brown seaweed and blue mussels have decreased by 250 pct. But levels of lead are still elevated and locals are advised not to harvest mussels along a 5 km coastline near the old mining site.
Case 2; the Qullissat coal mine (1924-1972)

The story of the coal mine near Qullissat, Disco Island, is the story about a living community that developed around the mine and disappeared again when the decision to close the mine was made. The closure of Qullissat is still remembered and is an important part in the formation of modern Greenland.

The mine opened in 1924 and during the next 15 years more than 60,000 tons of coal was mined here. The old resource was emptied, but activities moved to nearby Nungarut where production exceeded 6,000 tons a year. A small community developed with the mine as most of the 150–200 workers in the mine brought their families to the northern shores of the Disco Island. Within a few years the town of Qullissat had 900 inhabitants and in the 1960’s the town had developed to become the third largest town in Greenland.

During the 1960’s discussions about the profitability of the coal mine developed. The mine was in the red and committees were established to discuss the quality of the coal from Qullissat, the value of the operations and the importance of having national coal production to reduce the dependency on foreign production.

In 1972 the decision to close the coal mine in Qullissat was made despite widespread protests in Greenland. This decision dramatically influenced the lives of many families, as 1,400 people were forced to leave their homes and start new lives. Qullissat families moved to towns across West Greenland, but many experienced difficulties settling in and finding new jobs outside mining.

![Abandoned houses in Qullissat. Picture from http://blog.greenlandphotos.net/#post9](image)

The closure of the Qullissat coal mine sparked widespread protests which later led to the formation of the first political parties and eventually to the introduction of Greenland Home Rule in 1979.
Today the memories of Qullissat are still alive. In the summer 2012 families and descendants from the Qullissat community travelled back to commemorate the 40 year anniversary of the closure of the community. One of the prominent participants was then Premier Kleist, born in Qullissat. He married that summer on the site, where the Qullissat church once stood.

The old coal mine in Qullissat is an important part of Greenland’s political history and references to the 1972 decision are still made in public and political debates today.
Case 3; the Mestersvig lead and zinc mine (1956 – 1963)

Nordisk Mineselskab/ Nordic Mining operated a lead-zinc mine from 1956 to 1963 near Mestersvig, NE Greenland. The mine was located 10 km inland from Kong Oscars Fjord. A small road connected the mine with a harbor – Nyhavn – where concentrate was shipped to foreign markets.

During eight years of mining a total of 554,000 tons of ore was mined in Mestersvig. 58,000 tons of lead concentrate, and 75,000 tons of zinc concentrate was produced and shipped to European and North American markets. Tailings from the mine, an estimated 400,000 tons, were discharged on a nearby mountain slope from where much has slid into the river Tunnelelv and into Kong Oscars Fjord.

When the first environmental studies were conducted at the site in 1979, they documented high levels of lead and zinc in the sediments of Tunnelelv and the river delta at Kong Oscars Fjord. Of the 400,000 tons of tailings produced by the mine, only 66,000 tons remained in the original disposal area. Elevated lead and zinc levels were found in brown seaweed on the south coast of Kong Oscars Fjord, and in lichens elevated levels of zinc and lead were found up to 10 km from the mining site, documenting airborne distribution of metals from the site.

Mitigation efforts have been considered, e.g. covering the most polluted areas with gravel and shielding it from the fjord with a layer of bentonite. This would significantly reduce lead pollution from one source – concentrate spillage - but it would not affect pollution from another main source – tailings dispersed over vast areas. Mitigation efforts were not implemented as measures were considered too costly and ineffective (Johansen et al, 2008).

50 years after lead-zinc mining ended in Mestersvig the mineralogy of the areas is of continued interest. Molybdenum resources were discovered in nearby Malmbjerget in the 1950’s, but where then too difficult to mine. Increased demand has now sparked new interest in the molybdenum resource in Malmbjerget. A license for exploration activities was granted to International Molybdenum Plc., since 2007 a subsidiary of Quadra Mining Ltd. Field work and feasibility studies were prepared, documenting a resource of 217 million tons of ore with an average grade of 0,12 pct. molybdenum.

In 2008 Quadra Mining Ltd. was granted an exploitation license to establish an open-pit mine at Malmbjerget by 2012. Infrastructure for the mine would include a camp, a 75 km transport corridor from the mine to a harbor and an air strip established in Gurreholm. Concerns were raised as the facilities would disturb the northwestern parts of RAMSAR site Heden, established in
1988 to protect internationally important populations of moulting pink-footed geese (*Anser brachyrhynchus*) and barnacle geese (*Branta leucopsis*). Of importance for the designation were also other breeding birds like divers, waders and skuas together with uncommon breeding birds like Sabine’s gull (*Larus sabini*) and (whimbrel *Numenius phaeopus*). The Greenland Government announced the molybdenum project of “urgent national interest” and a replacement RAMSAR site was negotiated (see figure 7 below) (Glahder et al., 2011).

![Figure 7 Map of RAMSAR site Heden and RAMSAR replacement site Ørsted Dal. Malmbjerget molybdenum resource is indicated with a star. (DMU, 2011).](image)

The license for the area rests with Malmbjerget Molybdenum A/S for the period 2012-2016 and according to the Mineral License and Safety Authority, Greenland Government the project is pending better market conditions (Greenland Government, 2012).
Case 4; the Maarmorilik mine (1936-1940, 1966-1971)

The first mining activities in Maarmorilik (Greenlandic: the place with marble) started in 1936 when operations were moved from the nearby Agpat Island (1933-36) to the Maarmorilik site in Qaamarujuk fjord northeast of Uummannaq.

The resource of marble was rich and from 1936-1940 approximately 3,000 tons of marble were produced and shipped to Denmark. Records show that two teams of 18 men worked 12 hours shifts in the open mine, and new technologies and tools were introduced to keep the mine in operation during the winter of 1936-37 (Jacobi, 1967).

In April 1940 German troops crossed the borders of Denmark and activities in Maarmorilik came to a standstill. Activities resumed in 1966, and during five years of operation Greenland Stone A/S produced 5,000 tons of marble until the mine closed again in 1971.

During the first period of operations in Maarmorilik new resources were discovered. In 1939 a sample containing lead and zinc was found below the nearby mountain Vingefjællet. This resource developed into the Black Angel mine (1972-1990).
Case 5; the Black Angel mine (1972 – 1990)

Greenex A/S bought the Maarmorilik concession from Greenland Stone A/S, and after years of exploration activities mining of lead, zinc and silver from the Black Angel mine started in 1972. The resource was found high up in the mountain, 600 meters above the fjord, where a black coloring in the mountain has the shape of an angle. Using a cable car, ore from the mine was transported across the fjord Affarlikassaa to the processing plant and harbor near the old Maarmorilik mine.

Nearly 12 million tons of ore (average grades of 12 pct. zinc and 4 pct. lead) were extracted from the mine and transported across the fjord to the processing plant. From 1973 to 1990 411,400 tons of lead, 1,318,600 tons of zinc, and 248 tons of silver were shipped to foreign markets, mostly in Europe and North America (Johansen et al, 2008).

Figure 8 Maarmorilik processing plant and harbor seen from the Black Angel mine, 1976 (photo by Poul Johansen, from DMU website) (left). And the mining site today, with the two mine openings 600 m above sea level (from Angle Mining Plc. website) (right).

The Black Angel mine employed between 200 and 360 in full time jobs between 1973 and 1990. The mine provided jobs for foreign miners, but also for local workers as 4 in 10 miners were born in Greenland. But the benefits from the mine were not only in the jobs. The Black Angel gave the local community of Uummannaq a boost and tax revenues were invested in local infrastructure and fisheries; loan schemes for hunters and fishermen to invest in small fishing boats were established (Lodberg, 1993).
The concession for the Black Angel mine stated that the mining company should mitigate negative consequences that their activities may have on other activities in the region, including fishing and hunting. The local population was not informed about the potential risk of pollution until 1975 when Greenex A/S warned the local population not to fish near the mine. In 1976 it was documented that fish in the fjord system had elevated levels of lead and zinc and that the number of fish was reduced. In some areas wildlife was reduced overall – seals, eider and other sea birds were no longer found near the mine (Hertz, 1995).

Environmental monitoring of the Maarmorilik area and the Affarlikassaa and Qaamarujuk fjords has been conducted since 1972. Comparing samples of sea water, sediment and biota researchers document a drastic reduction in lead and zinc levels after the Black Angel mine closed in 1990. But pollution sources still exist at Maarmorilik as settled tailings and waste rock in the Affarlikassaa fjord still release small amounts of lead.

Concentrations of lead have been a cause of concern for public health. But 2007 samples document that lead concentrations are now below guidelines set to protect human health for all species except for blue mussels. The area affected by lead and zinc concentrations has become smaller over the years and today it is primarily in Affarlikassaa and Qaamarujuk that an impact can be seen (Johansen et al, 2007).

The environment of the Maarmorilik site is in focus again as the newly established Black Angel Mining A/S has obtained a license to reopen the Black Angel mine. Phase one plans are to mine the known resources (five years), while phase two is concentrated on developing new resources found within the license area (+ fifteen years). Samples on the ground have shown massive deposits of sulphide uncovered by a retracting glacier. The mineralization at this location was already known, but previously covered by 60 meters of ice. Samples documented 7 pct. zinc and 2.5 pct. lead (Angle Mining website, project overview).
Case 6; the Nalunaq gold mine (2004-2008, 2009-2013)

When the Nalunaq gold mine opened in 2004 it was a milestone. The mine was the first gold mine in Greenland and the first new mine to be developed in 30 years. But commercial mining of gold from this resource has proven difficult and in May 2013 the second license owner suspended all payments and activities of the mine.

Exploration for gold began in the late 1980s when geologists observed small flakes of gold in the gravel at the foot of the mountain Kirkespiret. Nuna Minerals A/S was granted an exploration license for the site in 1990 and the basis for commercial mining of gold was laid.

The name Nalunaq translates into ‘the place that is hard to find’, maybe as a reflection of the mining site. In 1992 primary gold was located 500 m above sea level at the slopes of the valley Kirkespirdalen. The gold was visible in outcropping quartz veins and occurred over an area of 800 m in length.

The basis of the operation was estimated to be an ore reserve of 400,000 tons with a gold grade of 21 grams per ton. Furthermore, there were indications of an extra resource at 1,670,000 tons with an average gold grade of 18 gram/ton (GEUS, 2008), (GeologiskNyt, 2003).

In 2004 Crew Gold Cooperation was granted a license to mine the gold deposit at Nalunaq. From 2004 to 2008 Crew Gold Operation completed more than 19,000 meters of tunneling and produced 308,000 ounces of gold. As Crew Gold Cooperation had no license to process the mined ore in Greenland, ore was shipped to Newfoundland, Canada. As oil prices rose the cost of shipping ore made activities less profitable and by the end of 2008 Crew Gold Cooperation closed down the mine.

Arctic Mining Ltd., a subsidiary of Angle Mining Plc. also leading efforts to re-open the Black Angel zinc and lead mine in North Greenland, in 2009 purchased the Nalunaq mining assets and reopened the mine. The mine operated until the first months of 2013 when it suspended all payments and activities. During the March 2013 election campaign, political discussions focused on the potentials for mining and hydrocarbon activities in Greenland with a focus on creating new jobs and new incomes outside fisheries. Two months after the election, it was clear that the only active mine had stopped all activities (Politiken, 11 May 2013).
Figure 9 Nalunaq gold mine. Picture by Joachim Adrian (http://politiken.dk/indland/ECE1967740/groenlands-mineeventyr-er-i-krise/).
Case 7; Kvanefjeld uranium research activities (1958-1981)

In 1956 deposits of uranium and thorium were documented in stenstrupin samples from Kvanefjeld (Kuannersuit) in the Ilimaussaq complex of South Greenland and ever since the Kvanefjeld deposits have been subject to political discussions, most recently in the 2013 election campaign.

In the same year as the deposits were first mapped by geologists, Research Center Risø was established in Roskilde, Denmark. The center was to research the potential for nuclear energy production in Denmark and three research reactors were established. Nuclear energy production became increasingly controversial, campaigns rallied against nuclear energy production, and by 1985 the Danish Parliament decided to stop all plans to develop nuclear energy and focus national energy strategies on conventional energy sources and new sources, including solar and wind.

From 1958 to 1981 the Danish state-owned Research Center Risø conducted exploration activities and drilling programs in Kvanefjeld. Four drilling programs were completed with a total of 66 drillings and a length of approximately 10,000 meters. In 1983 Research Center Risø estimated the deposit to be 56 million tons of ore with an average grade of uranium of 365 grams /ton. The deposit was therefore estimated at 20,500 tons of uranium. But to mine the area an open mine would need to be established and 136 million tons of rock would have to be removed (GEUS, 2012).

By comparison, the Kvanefjeld deposit of uranium is relatively small and with a low average grade. Uranium mines in production have average grades between 1,000 and 10,000 grams of uranium /ton. But recent studies have documented a large resource of rare earth elements (REE) here and deposits in other sites too, and the EU estimates that Greenland would be able to supply 25 pct. of the worlds demand for REE over a period of 50 years (Ingeniøren, 2011).

The most recent resource estimate (March 2011) includes a metal inventory of 6,6 million tons of total rare earth oxides, 350 million pounds of uranium (U₃O₈) and 3 billion pounds of zinc (Greenland Minerals and Energy Ldt., website). As it stands, uranium is only a byproduct of the rare earths mining. But uranium could become a main product and Greenland could move into the top-five of the world’s largest uranium exporters with the potential of bringing revenues at USD 20 billion a year (Foreign Affairs, 2013).

Greenland Minerals and Energy A/S plans to produce a range of products, including rare earth hydroxides and carbonates, uranium and zinc. Each product has a ready market and in the case of uranium oxide, heavy rare earth hydroxide and to a lesser extent, mixed rare earth carbonate demands are expected to exceed supply in 2015 (Greenland Minerals and Energy Ldt., 2012).

The complex mineralogy of the Kvanefjeld deposit, including thorium, fluor, REE, lead, lithium, beryllium, manganese, gallium, yttrium, zirconium, niobium and zinc, makes it an environmentally
complex site to mine. Fluor is a concern as it can be released into the environment, and environmental studies must document that tailings can be safely deposited. Potential plans for deposits of tailings in the Taseq Lake or preparing marine deposits in the end of Bredefjord by Research Center Risø have been contested. A future environmental impact assessment must establish how Greenland Minerals and Energy A/S plans to safely deposit tailings from the mine. One article about the environmental difficulties of mining Kvanefjeld contains information about 56 million tons of tailings containing uranium and thorium that may be deposited in a nearby lake. Geologist Per Kalvig, GEUS, explains that uranium and thorium tied in stenstrupin will be processed, but that tailings from the mine will have concentrations of uranium and thorium that cannot be processed.

Gert Asmund, senior researcher at the Department of Bioscience, Arctic Environment, University of Aarhus, explains that studies must be conducted to understand what may be dissolved from tailings if deposited in the lake and how this may influence stream and fjords. But water from the lake that may be used to deposit tailings can run into Narsaq River, where Arctic char is found. (Ingeniøren, 5. November 2013). One potential risk is that tailings from Kvanefjeld have concentrations of lead too. Greenland has experienced pollution from the old Maarmorilik mine where tailings were deposited in the fjord (see case 4 and 5 above).

Environmental NGOs have voiced concern about plans to mine REE and uranium. Initiated by Avataq, Noah and Det Økologiske Råd a total of 48 organizations in Greenland and abroad, including WWF, signed a petition against the plans to allow for mining uranium in Greenland (Avataq et al, 26 April 2013.)

The zero-tolerance policy on uranium and other radioactive minerals was lifted by the Greenland Parliament on October 24 2013 (see section 3.1 Jurisdiction).
Case 8, the Seqi olivine mine (2005-2009)

In 2005 SEQI Olivine A/S (later Minelco A/S) established a mine in Seqi between Nuuk and Maniitsoq. In the first year of production 92,000 tons of olivine was shipped from a temporary storage and harbor facility, and in 2006 the owners invested in a permanent harbor and processing facility with production climbing to 500,000 tons.

The ambition was to produce 2 million tons of olivine for foreign markets, but production was halted in October 2009 as shipping costs increased. The 40 – 45 workers who had worked in the mine lost their jobs.

The resource is estimated to be 100 million tons of olivine, which would allow for mining in the area for 50 to 100 years. Currently there are no plans to re-open the mine.

Figure 10  In 2011 clean up at the old site was conducted by KJ Greenland A/S on behalf of Minelco A/S. 800 m$^3$ of iron was collected from the site, but infrastructure remains at the site. Picture from http://www.kj.gl/?p=342

Environmental studies document elevated concentrations of chromium and nickel measured in lichens at a distance of up to 8 km from the mine, indicating a significant spreading of dust related to the mining activity. Closer to the mining site concentrations were 100 – 200 times higher than levels measured at reference sites. Elevated concentrations of chromium and nickel were also observed in blue mussels and brown seaweed, but only at a few stations near the mining site. Blue
mussels and brown seaweed from these stations were categorized as insignificantly to moderately polluted, while fish found in the fjord and lakes near Seqi showed no elevated element concentrations. The impact of the mine on the marine environment is very local and regarded as insignificant for the Niaquungunaq fjord system (Søndergaard et al., 2009).

Controlling dust from the mining operation may have been a challenge at Seqi, but WWF has not been able to find any studies discussing the potential consequences of dust on the health of the Seqi mine workers.

2.2 Resources development to the benefit of society

In November 2012 a newspaper chronicle in a Danish newspaper sparked a new debate about the relationship between Greenland and the other parts of the Kingdom (Politiken, 2012). The writers - then Premier Kleist and professor in geology at the University of Copenhagen Minik Rosing – made a call for cooperation and knowledge to support a sustainable development of new industry in Greenland.

Fourteen months later the Committee for Greenlandic Mineral Resources to the Benefit of Society led by Professor Minik Rosing presented a report on how Greenland society should benefit from the mineral resources found here (Udvalget for samfundsgavnlig udnyttelse af Grønlands Naturressourcer, 2014). Established under Ilisimatusarfik/University of Greenland and University of Copenhagen a committee of 13 researchers set out to establish a knowledge base on which the Greenland public can debate the benefits and consequences of new industry development.

The report gives an introduction to the rich mineral resources of Greenland and then goes on to describe five scenarios for development. The scenarios are used to describe paths of development that Greenland can take and to highlight consequences. 23 focus areas – consequences and challenges that decision makers should pay attention to when developing mineral resources industry - are highlighted. The very first of the twenty-three is the need for a thorough debate about new industry and the consequences new industry will have on society.

The committee draws a clear picture of change with the report. ‘Resources are an opportunity for change – not for status quo’ the report reads. Greenland is part of a globalized world and Greenland will change as does the rest of the world. But change can be dramatic where ‘human interaction with the sea and the living resources is a core part of Greenlandic identity’ (Udvalget for samfundsgavnlig udnyttelse af Grønlands Naturressourcer, 2014).

Five scenarios for resources development are given in the report. Four of the scenarios build from the current situation, where Greenland explores opportunities for resources development but still
receives a subsidy from the Kingdom of Denmark. The last scenario is a scenario where Greenland is economically independent of the Kingdom of Denmark.

Status quo (scenario 1) is not viable for Greenland, as projections show that public expenditures will increase into 2014 as a consequence of demographic changes. A growing budget deficit can be bridged with increased taxation and/or dramatic cuts in welfare services and education.

A second scenario is for Greenland to ‘develop a mining industry to the scope allowed by its mineral deposits and at the pace permitted by the international marked’ (Udvalget for samfundsgavnlig udnyttelse af Grønlands Naturressourcer, 2014). This is an all in strategy. With an average life cycle of 10 years and revenues of DKK 700 million a year, Greenland will need to develop a new large-scale mining project every second year. In conclusion, 24 concurrent large-scale mining projects would be required to zero out the Danish subsidy. This scenario may have dramatic social and environmental consequences for a small country of only 56,000.

The idea of a natural resources wealth fund is discussed under scenario three and four. Greenland has established a fund by law (after the Norwegian model) but the fund has not yet been used as revenues have been limited. Political discussions about the need for preserving resources for future generations as supposed to taking care of immediate needs have evolved, but here the committee offers clear advise. For a sustainable development revenues must be placed in a wealth fund and only interests from the revenues may be used today.

The committee makes a note of the value of natural resources. The living resources of the Greenland waters can be 20 times the value of minerals as well-managed stocks can be harvested over and over. In contrast, mineral resources are not renewable and exploration of these resources is reducing national wealth.

The committee then discusses a multi-pronged strategy (scenario 4) where mineral resources activities are developed along with other industries. An important part of this scenario is that the Government must control and guide industry development. A first step is to identify go-zones where industry can be to the benefit of society – and no-go-zones where resources development activities cannot take place as there is a need to protect living resources. A second step is to focus development on a limited number of projects. The outcome of this strategy will be for Greenland to focus on setting up about five large resource projects located outside zones of special natural and cultural value.

The last scenario – ‘an independent self-sustaining Greenlandic economy based on mineral resources contains an intrinsic dilemma’. The committee describes this all-in scenario as difficult because it would require such extensive foreign investments and massive inflow of foreign labour that there is a risk that the current Greenlandic population would become a minority in Greenland. This scenario will leave many impacts on nature and environment and with rapid development
there is a risk that the local work force will be pushed out of the lucrative new labour marked, leaving little positive impacts for the Greenland society.

The committee concludes that ‘Greenland will be hard pressed to achieve financial balance solely with fishing at the current levels, the block grant and mineral extraction, and it must be considered highly unlikely that a sustainable economy can be created without the need for subsidies over the next 25 years’.

This conclusion does not take into account the development of hydrocarbon resources in Greenland. The committee estimates that: ‘if all goes well the extraction of minerals could begin to contribute significantly to Greenland’s economy within five to ten years’. In contrast, production and export of oil is still 20 to 50 years into the future (Udvalget for samfundsgavnlig udnyttelse af Grønlands Naturressourcer, 2014).
3. Governing resources

Greenland was a colony of Denmark until 1953, when an amendment of the Danish Constitution was made and Greenland became a constituency within the Danish Kingdom alongside the Faroe Islands. Modernization of the Greenlandic society led to the establishment of Greenlandic political parties and demands for greater economic and political independence in the 1970s. In January 1979 the Greenland Home Rule was established after a referendum, where two-thirds of the population voted in favor of increased independence².

30 years later Greenland Self-Government was established. In accordance with the Self-Government Act of 12 June 2009, the Self-Government authorities in Greenland exercise legislative and executive power whereby the legislative power lies with Inatsisartut (Greenland Parliament), executive power with Naalakkersuisut (Greenland Government) and the judicial power with the Self-Government established courts of law³.

Since 1979, many areas of responsibility have been taken over by the Greenland Government, e.g. health services, education and culture. Of special relevance to nature and conservation is the fact that Greenland has jurisdiction and management responsibilities for conservation of flora and fauna, protection of the environment and management of living resources. Protection of marine environment is divided between Greenland and the Kingdom of Denmark (see below).

3.1 Jurisdiction

Greenland today has jurisdiction over the mineral and hydrocarbon resources found within the Greenland territory (the Greenland EEZ). This follows from the 2009 Act on Greenland Self-Government ( §§ 2-4 on the Self-Government authorities’ assumption of fields of responsibility) and the 2009 Mineral Resources Act.

§ 9 of the Mineral Resources Act, covering both hydrocarbons and mineral resources, reads: ‘The Greenland Parliament Act extends to the territorial land and territorial sea off Greenland and in the continental shelf area and the exclusive economic zone off Greenland’.

2009 Act on Greenland Self-Government

The Act on Greenland Self-Government introduced new principles to the economic relationship between Greenland and the Kingdom of Denmark, provisions on how revenues from hydrocarbon and mineral activities are to be shared and language on Greenland’s access to independence. But the act is also important from a cultural perspective. In the preamble the people of Greenland are acknowledged as a people pursuant to international law with the right to self-determination. The act is based on a wish to foster equality and mutual respect in the partnership between Greenland and Denmark. Greenlandic is recognised as the official language of Greenland.

The Act on Greenland Self-Government also establishes the future economic relationship between Greenland and the Kingdom of Denmark. Under Greenland Home Rule (1979-2009) the annual subsidy for Greenland was negotiated and new fields of responsibilities were transferred with funding.

With the Act on Greenland Self-Government the annual subsidy is now set at DKK 3.4 billion, but adjusted annually according to the general price and wage index of Denmark.

Increasingly relevant in relation to the economic relationship between Greenland and the Kingdom of Denmark is the exploitation of mineral and hydrocarbon resources in Greenland. In relation to revenue from mineral resource activities in Greenland, the Danish subsidy to the Self-Government authorities will be reduced by an amount corresponding to half the revenue which in the year concerned, exceeds DKK 75 million. In accordance with the Act on Greenland Self-Government (§10), negotiations shall be initiated between Naalakkersuisut and the Danish Government regarding the future economic relations between Greenland and Denmark if the subsidy is reduced to zero kroner (that is, if revenues from export of mineral resources from Greenland exceeds DKK 6.8 billion).

Scenarios for mineral resources development, including a scenarios where mineral resources activities zero out the subsidy and Greenland is economically independent from Denmark, is discussed in a recent report by the Committee for Greenlandic Mineral Resources to the Benefit of Society (see section 2.2).

The 2009 Greenland Self-Government Act contains agreed language on Greenland’s access to independence. Decisions regarding Greenland’s independence shall be taken by the people of Greenland in accordance with § 21. An agreement between the Greenland Government and the Danish Government regarding introduction of independence for Greenland shall be concluded.

4 The 2009 Act on Greenland Self-Government establishes the annual subsidy with § 5: ‘(1) The Government shall grant the Greenland Self-Government authorities an annual subsidy of DKK 3,439.6 million, but see section 8 (1). The amount is indicated in 2009 price and wage levels.(2) The subsidy shall be adjusted annually in accordance with the increase in the general price and wage index of the Finance and Appropriation Act for the year concerned’.
with the consent of the Greenland Parliament and shall be endorsed by a referendum in Greenland. The agreement must also be concluded with the consent of the Danish Parliament.

The 2009 act also states that independence for Greenland implies that Greenland assumes sovereignty over the territory of Greenland.

Since the Greenland Home Rule was introduced in 1979 foreign affairs and politics have become a much more integrated part of many policy areas, e.g. in relation to protection of the marine environment, conservation of flora and fauna, management of fisheries and in relation to new forums like the Arctic Council.

The Kingdom of Denmark has the constitutional responsibility for and power to act in international affairs on behalf of Denmark, Greenland and the Faroe Islands. But much has happened since Greenland Home Rule was introduced in 1979; therefore the Greenland Self-Government Act establishes that the Danish and Greenlandic Governments must cooperate in international affairs with a view to safeguard the interests of Greenland as well as the interests of the Kingdom of Denmark.

The Greenland Government may, on behalf of the Realm, negotiate and conclude agreements under international law with foreign states and international organizations if these agreements exclusively concern Greenland and entirely relate to fields of responsibility resting with the Greenland Government.

Likewise, before the Danish Government initiates negotiations regarding agreements under international law which are of particular importance to Greenland they must inform and if requested by the Greenland Government, make an agreement that sets a frame for these negotiations.

There are many examples that reflect how the Kingdom of Denmark must take into consideration the interests of Greenland and negotiate a common position between Denmark, Greenland and the Faroe Islands before entering into international negotiations. Under the International Whaling Commission, negotiations on quotas for aboriginal subsistence whaling is of particular interest to Greenland and therefore the Greenland Government is actively engaged in meetings and negotiations. When the Kingdom of Denmark ratified the Kyoto protocol, the Government of the Faroe Islands asked for a territorial exclusion while the Greenland Government agreed to GHG reduction targets as negotiated in a bilateral agreement between Greenland and Denmark.

2009 Mineral Resources Act

The 2009 Mineral Resources Act completed the transfer of responsibility for mineral and hydrocarbon resource governance from Denmark to Greenland. In the fall 2012 an amendment to
the 2009 act was passed by the Greenland Parliament\textsuperscript{5}.

The Mineral Resources Act establishes the Mineral Resources Authority under the Greenland Government as the overall administrative authority for mineral resources, including all matters relating to mineral resources, mineral resources activities, use of subsoil for storage and purposes related to mineral resource activities, including energy production, pipelines etc. (§ 3).

The 2009 Mineral Resources Act established an administration based on a one-door principle. The idea was that industry interested in establishing themselves in Greenland should have only one entry point into the Greenland Government - the Bureau of Minerals and Petroleum. Since 2009 the administration has been under criticism for not being transparent, for handling both the promotion of the project and the nature and environmental aspects of licensing and for being without parliamentary control (Sermitsiaq. AG, 4 October and 9 October 2012).

The 2012 amendment to the Mineral Resources Act establishes a new structure, where environmental and nature aspects of licensing now rest with a new agency; The Environmental Agency for Mineral Resources Area/ Miljøstyrelsen vedrørende Råstofaktiviteter under the Ministry of Nature and Environment. But the agency is small and the legal foundation for its work is still the Mineral Resources Act alone. The new structure was introduced on 1. January 2013 and it still remains to be seen what the effect of this new organisation has on administration. NGOs in Greenland have voiced their concerns that this is not de facto a separation of powers and agency, and with only two full time employees it will have little impact on future management of resources (KNR, 20. June 2013)

A parallel regime for polluting industry is established with Chapter 5 of the Environmental Protection Act, but this regime only applies to non-mineral resource activities, e.g. for setting standards for storage of fuel, emissions or handling of waste from local industry etc. As an example; standards for storage of fuel for a helicopter used in relation to prospecting of zinc in North Greenland will be set in accordance with the Mineral Resources Act, not the Environmental Protection Act. In contrast, the Environmental protection Act applies to the Alcoa aluminium smelter project as well as to the small, local mechanics shop as none of them are extracting resources from the subsoil of Greenland.

In the political debate a merger of the two parallel regimes into one has not been on the agenda, but this might be the long-term consequence of the newly established Environmental Protection Agency for Mineral Resources Activities. With a small government administration and few resources available it may well be a more effective regime if there was one regime established for all industry in Greenland, and maybe most effective if this regime allowed for differentiation between small scale industry with few and local impacts and large scale industry with potentially


[54]
With the new coalition agreement (Siumut, Atassut and Partii Inuit, April 2013) parliamentarian control is re-established with the mineral resources committee. Since 2009 when the old Danish/Greenlandic joint commission for mineral resources development was abandoned, there has been a strong criticism that members of the Greenlandic parliament had little access to information about license practices and environmental standards. A new mineral resources committee was established at the 2013 spring session of the Greenland Parliament. This committee must be informed before licenses for new activities are issued. Members of the committee therefore protested when the Minister for Minerals and Industry in an interview with Danish media discussed a near and possible date for granting London Mining an exploitation license for a large scale iron ore mine near Nuuk without prior consultation with the Greenland Parliament mineral resources committee.

Criticism has also focused on the fact that access to appeal has been unclear. With the 2012 act, appeals regarding decisions made by the Bureau of Minerals and Petroleum or the Environmental Agency for Mineral Resources Area can be submitted to the Greenland Government. Those entitled to appeal are parties to the case, all considered as having a vested, individual interest in the outcome and finally associations and organizations, which have a statutory aim to safeguard important interests in relation to recreational and environmental issues as well as issues relating to nature or society (§ 3b).

The new government has plans to introduce a new control authority for mineral and hydrocarbon activities. The authority has not been established yet and it remains to be seen what its role will be in discussions about licensing and the public’s access to information about concrete mineral and hydrocarbon development projects.

**Questioning jurisdiction: lifting the zero-tolerance policy on uranium mining**

The potential for mining rare earth elements (REE) and uranium at Kvanefjeld (see case 7) sparked a diplomatic dialogue and open debate between Nuuk and Copenhagen as the Greenland Minerals and Energy (GME) mining project challenges the understanding of Greenland’s jurisdiction under the Act on Greenland Self-Government.

In 2010 the Greenland Government granted GME a license to conduct exploration activities in Kvanefjeld. This was an exemption to the zero tolerance policy; a 60 parts per million (ppm) limit established in 1988 de facto prohibits mining of uranium and other radioactive minerals in Greenland.

With the license GME was allowed to conduct drilling at the site estimating the resource and conducting surveys on how the site could be mined. The exemption delayed the debate about potential uranium mining in Greenland, but Greenland Minerals and Energy made it clear that by-
products uranium and zinc are important parts of the resource: ‘Kvanefjeld differs to many other emerging REE projects, in that it is a multi-commodity project that is anticipated to also produce uranium and zinc. These co-products serve to provide a strong economic keel to the project’s economics, and ensure a low equivalent cost of rare earth production’ (Greenland Minerals and Energy, website).

Greenland Minerals and Energy has established the resource at 575 million pounds of uranium U3O8, which brings Kvanefjeld into the top 3 of the world’s known resources (Greenland Minerals and Energy Ltd., 2012)

The debate about the lifting of the zero tolerance policy was revitalized in March 2013, when the newly elected coalition of Siumut, Atassut and Partii Inuit announced that ‘the zero tolerance for uranium is to be lifted. Considerations for health, nature and environment must be made’ (Siumut, Atassut and Partii Inuit, 2013, p. 3 (WWF translation).

Locally, concern focused on the environmental and health aspects of mining at a site only 5 km from Narsaq. Critics voiced concern that dust from the open-pit mine will negatively affect the health of miners and the local population, that dust can negatively affect small-scale farming in the area, and that lakes, streams and fjords can be polluted if tailings and chemicals are not handled safely. But the Narsaq region also shows support for the project as a mine will bring 400 – 500 new jobs and investments to a region much in need of new investments and jobs.

On a national level, the protest organization Naamik Qujaanarpunga (Greenlandic: No thanks) was established. Closely linked to opposition party IA, the organization argued that Greenland should focus on other mineral resources but refrain from developing uranium. Arguments were made both out of concern for the consequences of mining uranium in Narsaq and the challenges associated with uses of uranium, e.g. the safety and waste-handling at nuclear power plants. Naamik brought people together in towns across Greenland for protest demonstrations and on the night before the parliament debate, 400 people stood outside the Inatsisartut building in Nuuk, Greenland. Reporters called this the biggest protest in 29 years.
Naamik also brought forward the need for an informed debate and a national referendum before lifting the zero tolerance policy. Minister of Industry and Minerals Kirkegaard was first asked to comment on the need for a national referendum. In his answer, he made it clear that he considered the public informed and consulted already. And he stressed that during the election campaign it was clear to everyone that casting a vote for Siumut meant casting a vote for lifting the zero tolerance policy (KNR, 19. August 2013). Siumut supporters later expressed their disagreement with Minister Kirkegaard.

The debate about consultation of the public was brought forward again during the fall session of the Greenland Parliament. Coalition leader Hammond argued that there was no need for a national referendum, but brought forward the idea that the local population of South Greenland should be involved. This was refused by the opposition, who argued that mining and exporting uranium would affect the entire country and should be subject to a national debate followed by a referendum.

During the parliament debate it was clear that there was disagreement about the lifting of the zero tolerance policy both between the three coalition parties and within the Siumut party. One the day before the final parliament debate, disagreement led to the dramatic exclusion of Partii Inuit as MP Brobjerg refused to vote in support of lifting the zero tolerance policy. But disagreement spread inside the Siumut party too. Former party leader and premier Enoksen openly advocated for a national debate and referendum in opposition to the Siumut party.
position. Enoksen voted against lifting the zero tolerance policy, but the vote ended 15/14 (Sermitsiaq.AG, 23. - 24. October 2013), (Danmarks Radio, 24 October 2013).

With the parliament vote Greenland can now grant Greenland Minerals and Energy Ltd. a license for exploration of REE, zinc and uranium at Kvanefjeld. Studies of the impacts on environment, nature and society are to be conducted and environmental standards will be set in accordance with the Mineral Resources Act. An Impact Benefit Agreement negotiated between the licensee, the government and the local municipality of South Greenland, Kommune Kujalleq, will set standards for local job creation, trainee positions, involvement of local companies etc.

But a question that remains unanswered is whether Greenland can export its uranium. This central and relevant question challenges the division of jurisdiction between Greenland and the Kingdom of Denmark. While the 2009 Act on Greenland Self-Government answered some questions and established principles about the rights to the resources found in Greenland, developing these resources into projects has brought new complexities to the relationship between Greenland and the Kingdom of Denmark.

Asked to comment on the Greenland Parliament decision to allow for mining of uranium in Greenland, Danish Premier Thorning carefully stressed the fact that Greenland now has the right to make decisions about exploration and exploitation of oil, gas and minerals found in Greenland. She then emphasized the ongoing dialogue with Greenland, but made it clear that: ‘there may be aspects of uranium mining and export which are related to foreign affairs, defense and security and thus under jurisdiction of the Kingdom of Denmark’ (Danmarks Radio, 25 October 2013).

When the debate on the zero tolerance policy made it into the public debate in Greenland and Denmark, it was after a lengthy diplomatic dialogue and exchange of opinions based on expert studies had first started.

The Greenland Government in cooperation with the National Centre for Environment and Energy (DCE) and Lett Advokatfirma first prepared a report wherein the argument is made that Greenland has the right to mine and export uranium as long as the uranium is used for peaceful purposes (Grønlands Selvstyre, April 2013). The report reads: ‘international agreements on the mining, sale and export of uranium may affect aspects of national defense and security. But agreements concerned with the peaceful use of uranium will not affect the defense and security of the Kingdom of Denmark. Furthermore, the Kingdom of Denmark will have no objective (legal) interest in preventing the mining, sale and export of uranium to be used for peaceful purposes, including energy production. But the Greenland Government must inform the Danish Government about negotiations and signing of such agreements [...] (Greenland Government, April 2013, p. 20 (WWF translation)).
Before the Greenland Parliament debate, Danish Minister of Foreign Affairs, Søvndal, travelled to Greenland for a dialogue with Premier Hammond. At a press conference in Nuuk Søvndal said: ‘in some situations Denmark and Greenland agree to disagree. The centre of the disagreement is the division of jurisdiction between Greenland and Denmark as given by the Constitution and the Act on Greenland Self-Government’ (JyllandsPosten, 7 October 2013 (WWF translation).

The conclusions above were contested by a joint Greenland Government and Danish Government expert report, which was made public on October 7 2013 (Grønlands Selvstyre og Regeringen, Octobers 2013). This report made the Greenland Parliament push the first debate on the zero tolerance policy ahead one day, in order for members of parliament to study the report and its recommendations. The conclusion of the joint report is that mining and export of uranium does affect foreign affairs and defense- and security policy of the Kingdom of Denmark and therefore cooperation between Greenland and Denmark is needed. Building from the fact that there is almost no experience with and knowledge about uranium governance in Greenland and Denmark, ten recommendations for further studies and capacity building are made.

Consensus seems to be building that there is a need for close cooperation within the Kingdom of Denmark if Greenland is to export its uranium, and that Greenland and Denmark must study best practices for governing uranium. But there is disagreement about the time frame for uranium mining.

Westergaard and Bourgouin, researchers with the Danish Institute for International Studies (DIIS), argue that building knowledge and capacity to handle uranium export from Greenland will take 5 to 10 years. In a policy brief, they conclude that ‘given that Greenland could become a large exporter, with upwards of 2000 tons of production per annum anticipated an efficient system of accountancy and control to facilitate paperwork and standards will be required [...]. It will also require a public administration that is educated in proliferation networks, the nuclear fuel cycle, and political developments surrounding nuclear weapons and countries of proliferation concern. This is doable but the non-nuclear status of Denmark is a challenge as it means that Denmark and Greenland are both innocent and uninformed in these areas [...].’ (Westergaard and Bourgouin, DIIS, 2012).

Greenland Government disagrees with the lengthy time frame given by the DIIS researchers. Asked to comment on the 5-10 year horizon for exporting uranium Minister Kirkegaard stated that ‘much will depend on our partners. But we do not expect this to take 5-10 years. Our estimate is that it will take a few years’ (Politiken, 24 October 2013).

Westergaard in a comment stresses that the two reports mentioned above only document how complex this is and that time is needed to develop a shared policy on how to handle Greenland’s production and export of uranium, including the complexities of controlling exports (Politiken, 24
October 2013). A new research programme led by DIIS – Governing uranium – has been established to study best practices from uranium producers across the world.

With parliament’s vote to lift the zero tolerance policy on uranium mining, Greenland has taken the first step towards mining Kvanefjeld and becoming an important exporter of REE and uranium for the world market. There is deep concern about this development within parts of the Kingdom of Denmark and there is no doubt that the issues between Nuuk and Copenhagen will be ongoing in the years to come.

**Questioning jurisdiction: protection of the marine environment**

Another example of the complexities of jurisdiction between Greenland and the Kingdom of Denmark is related to the development of oil and gas resources offshore and protection of the marine environment.

In 1994 Greenland took over the jurisdiction for protection of coastal waters. The Greenland Marine Protection Act has provisions that protect the marine environment of coastal waters, defined as waters within 3 nm off the baseline (coast). Greenland Government, Ministry of Nature and Environment, is responsible for protection of the marine environment, including handling of oil spills.

More relevant in relation to this report is the protection of marine environment in relation to hydrocarbon exploration activities and shipping, mostly taking place in waters between 3 nm and 200 nm (the EEZ).

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6 Landstingsforordning nr. 4 af 3. november 1994 om beskyttelse af havmiljøet med senere ændringer.
For this vast territory, environmental protection and surveillance activities are responsibilities of the Realm. The Danish Ministry of Environment is overall responsible for marine protection and international conventions in relation to this whereas the Danish Ministry of Defense and the Danish Defense is responsible for surveillance activities within Greenland territory, including surveillance of the marine environment.

The Danish Marine Protection Act does not apply in Greenland, but with modifications the act or provisions of the act can be entered into force in Greenland by royal decree (§ 68)\(^7\).

A new § 68 (2), does give guidance on the division of jurisdiction and responsibilities in relation to mineral and hydrocarbon resources activities offshore Greenland. The new provision states that the Greenland Government has jurisdiction in relation to exploration and exploitation of mineral resources and hydrocarbon resources, and that all aspect of governance in relation to these activities are now the responsibility of the Greenland Government\(^8\). Any spills from mineral and

\(^7\) Lov om beskyttelse af havmiljøet LBK nr. 963 af 03/07/2013. https://www.retsinformation.dk/Forms/r0710.aspx?id=145889

\(^8\) § 68, Stk. 2. For virksomhed omfattet af tilladelser til undersøgelse og udnyttelse af mineralske råstoffer i Grønland, herunder kulbrinter, varetages myndighedsbeføjelserne og -opgaverne i henhold til loven, bortset fra beføjelser til at fastsætte regler i henhold til loven, af Grønlands landsstyre. Grønlands landsstyre kan som led i den samlede myndighedsbehandling af råstofaktiviteter i Grønland, jf. lov nr. 335 af 6. juni 1991 om mineralske råstoffer m.v. i
hydrocarbon related exploration and exploitation therefore falls under the jurisdiction of the
Mineral License and Safety Authority of the Greenland Government (previously Bureau of Mineral
and Petroleum). The recent Greenland country profile of the International Tanker Owners
Pollution Federation reads: ‘any spills from mineral and hydrocarbon related exploration and
exploitation activities fall under the jurisdiction of the Bureau for Minerals and Petroleum (BMP),
regardless of whether the spill is within or outside 3 nm of the Greenland coast’ (ITOPF, 2012).

As a result, corporations who plan to explore hydrocarbon resources in Greenland waters must
follow standards and guidelines issued under the Mineral Resources Act. Corporations must
guarantee funds for clean up in the event of a spill. And the Greenland Government must make
sure that licensees have the financial resources to guarantee a cleanup.

Greenland Oil Spill Response A/S has been established by the Greenland Government to see that
oil spill equipment and capacity to handle oil spills related to mineral and hydrocarbon activities
can be handled in Greenland rather than from abroad. Licensees must sign a membership with a
Greenlandic oil spill response company before operations can start. This will bring new capacity
for handling of spills to Greenland, but the company is still being developed with new equipment
and training programs.

Critics argue that jurisdiction is still unclear and that resources are currently not available to
handle a spill in waters off Greenland. For mineral and hydrocarbon activities the first resort is
always company contingency plans established by the licensee and approved by the Greenland
Government. Problems occur if company contingency plans are not sufficient to handle a spill.

The Greenland Mineral Resources Act sets standards for contingency plans and the Greenland
Government has underlined that licenses implement best international standards and practices
and rest on the polluter pays principle. This has been widely contested by critiques of the 2010-
2011 Cairn Energy operations in Greenland, arguing that contingency plans were faulty. Estimates
of a worst case scenario of blow out was too low resulting in oil-spill response measures being
inadequate to handle a large spill, and assessments of the environmental consequences of a
blowout would not take into account the full potential scale of an oil spill and that that financial
reassurance Cairn Energy may have provided the Greenland Government with may not have been
sufficient to cover damages (ICC Greenland, 2012), (Greenpeace, 2013).

In a worst case scenario where company contingency plans prove insufficient to handle a large
spill Greenlandic and Danish resources will be used to contain a spill and efforts will be led by the
Danish Defense. Late Minister for defense Hækkerup was asked to comment on the fact that the
Kingdom of Denmark may have to carry costs for clean-up in the event where a large spill cannot
be handled by the oil company. Hækkerup said that the Kingdom of Denmark is supportive of

Grønland (råstofloven) og lov om kontinentalsoklen, jf. lovbekendtgørelse nr. 182 af 1. maj 1979, fravige
bestemmelserne i loven eller regler udstedt i medfør heraf, hvor dette ikke strider mod internationale aftaler.
Greenland developing new industry based on the country’s resources. And he correctly stated that jurisdiction rests with the Greenland Government. But he did refused to comment on the fact that the Kingdom of Denmark would eventually have to cover costs associated with clean up of a large spill.

And clean up may be costly. For illustration BP costs for clean up after the Mexican Golf blow out in 2010 is currently at USD 35 billion. Greenland Government asks oil companies who work in Greenland to guarantee resources for clean up, but those guarantees do not cover spills of larger magnitudes (Information, 29. October 2013).

Another concern is whether Danish Defense has the capacity and resources to handle a large spill. Kai Sørensen, former deputy director at GEUS and Statoil employee, stated that the current capacity to handle a spill of 5,000 tons of crude oil is not sufficient. Following a debate about the risks of oil spills in the Arctic, he stressed: ‘often spills from exploration drillings are very powerful and can reach 30,000 tons a day. If there is a large spill up there [in Greenland waters] we can only pray and wait until it passes. This may result in unmanageable environmental disasters.’ (Politiken, 24. June 2013).

Rigsrevisionen - an independent public institution under the Danish Parliament, whose primary task is to audit the states accounts and examine whether Danish state funds are administered in accordance with the decisions made by Parliament – in the 2013 report expressed strong criticism of Danish marine protection activities in Greenland (Rigsrevisionen, 2013).

Rigsrevisionen states that search and rescue activities, maritime safety and marine environment in the Arctic: ‘are challenged by the harsh conditions of the region and by increased shipping. Increased cruise ship activities and shipping related to exploration of resources does increase the risks of accidents and pollutions, e.g. oil spill’ (WWF-DK translation).

Rigsrevisionen express concern that: ‘The Kingdom of Denmark’s efforts are not adaptive to the changes in risks for both environment and humans that increased shipping in Greenland waters have brought’ (WWF-DK translation).

Rigsrevisionen find that: ‘The Danish Defense monitoring of the marine environment and enforcement of marine environmental protection provision in Greenland has been inadequate’ (WWF-DK translation). Concretely, the Danish Defense has not prepared risk assessments for pollution of the Arctic marine environment, has not controlled shipping of hazardous materials in accordance with regulations and has not ensured that enough staff and equipment is in place to conduct the above activities.
3.2 Management, licensing and consultation processes

Resource development and management of new industry in Greenland rests with the Greenland Government in accordance with the Mineral Resources Act.

With the most recent revision of the Mineral Resources Act (1. January 2013) a new structure was introduced, dividing activities associated with mineral resources development into two separate agencies under the Ministry of Industry and Mineral Resources and the Ministry of Nature and Environment (Greenland Government website, www.bmp.gl).

The Ministry of Industry and Mineral Resources/ Departementet for Erhverv og Råstoffer is responsible for strategies and policy-making, for legal issues, marketing of the mineral resources in Greenland as well as socioeconomic aspects of mineral resources activities, including Social Impact Assessment, Impact Benefit Agreements and royalty schemes.

• The Mineral License and Safety Authority/ Råstofstyrelsen (formerly Bureau of Minerals and Petroleum) is the administrative authority for licensing issues and is the authority for safety matters, including supervision and inspection. The Mineral License and Safety Authority is a one-door entry point for licensees and other parties covered by the Mineral Resources Act.

The Ministry of Nature and Environment/ Departementet for Miljø og Natur is responsible for protection of nature and environment.

• The Environmental Agency for the Mineral Resources Area/ Miljøstyrelsen for Råstofområdet is a newly established agency which was established to oversee environmental aspects of licensing that were formerly under the Bureau of Minerals and Petroleum. The Environmental Agency for the Mineral Resources Area is the administrative authority for environmental aspects related to mineral resources activities, including protection of nature and environment, environmental liability and environmental impact assessments. The agency works with researchers with the Danish Centre for Environment and Energy (DCE) and the Greenland Institute of Natural Resources (GINR).

Decisions about licensing are made collectively by the nine members of the Greenland Government/ Naalakkersuisut after recommendations prepared by the Ministry of Minerals and Industry. The Parliamentary Committee on Mineral Resources must be informed, but need not be consulted, prior to any decision on licensing.

The licensing process

The framework for licensing processes is given in the Mineral Resources Act, sections 4 – 9, and in guidelines established by the Greenland Government.
With the 2012 amendment small-scale licenses, exclusive and non-exclusive, were introduced to the management regime. This regime was introduced to allow for individuals and small companies to harvest minerals and gem stones at a smaller scale, primarily for production of jewellery with gem stones.

The Greenland Government since 2012 has used eight licensing categories:

I. Applications being processed (confidential),
II. Mineral exploration licenses (exclusive),
III. Mineral exploitation licenses (exclusive),
IV. Mineral prospecting licenses (non-exclusive),
V. Petroleum exploration and exploitation licenses (exclusive),
VI. Petroleum prospecting licenses (non-exclusive),
VII. Small scale licenses for minerals (non-exclusive), and
VIII. Small scale licenses for minerals (exclusive).

The licensing process includes environmental impact assessments and social impact assessments according to legislation and Greenland Government guidelines (Greenland Government, 2013).

Impact Benefit Agreements are negotiated between the licensee, the Greenland Government and local authorities to see that communities benefit the most from new industries. NGO’s and other stakeholders are sometimes invited to discuss and give ideas about inputs for impact benefit agreements, but the negotiations with licensees are closed to the public.

Regulations reflect the investments that are made by licensees to estimate resources in tonnage and grade, estimate the reserve to be mined and prepare studies of environmental and social impacts of these operations. Therefore guidelines for mineral resource activities establish that if the licensee has found and delineated commercially viable deposits which the licensee intends to exploit, the licensee is entitled to be granted an exploitation license, provided the terms of the exploration licenses have been complied with (item 7.1 of the Greenland Government application procedures and standard terms for mineral exploration and prospecting licenses).

Public consultations

License for and approval of exploitation of minerals and hydrocarbons can be granted by the Greenland Government only after an assessment has been made on the impact of the environment (EIA) in accordance with § 73 of the Mineral Resources Act. Small-scale mineral exploration activities are not subject to provisions on EIA reports. The applicant must conduct studies and prepare the EIA report, including a non-technical summary. The Greenland Government can decide that additional material for the EIA is provided or that additional studies or assessments must be prepared of specific conditions of importance to the EIA. It is also the
Greenland Government that lays down provisions for the preparation and approval of EIA reports, including provisions on the material to be provided for the purpose of the assessment (§ 74). On public access to information the Mineral Resources Act established that information about the submission of an EIA report will be published on the Greenland Government’s website or in another suitable manner (§ 75).

If an activity related to exploration and exploitation of minerals and hydrocarbons may have significant impacts on social conditions, a license for and approval of that activity can be granted only when a social sustainability assessment (SSA) has been made to the performance of the activity and an SSA report has been approved by the Greenland Government in accordance with § 76. Parallel to the provision given for public access and information above, SSA reports will be published on the Greenland Government website.


The Greenland Government has prepared guidelines for Environmental Impact Assessments that sets standards for public involvement in the EIA process (Greenland Government, 2011). In accordance with these guidelines the public ‘should be involved throughout the EIA process and informed about the activities when the mine is in production’. The guidelines have recommendations for the applicant to host at a minimum one public consultation meeting early on in the process and for information on how issues brought forward in this consultation are addressed. A white paper is prepared with all public consultation objections and comments for the project as well as the applicant’s answers to these comments and how they have been addressed. Following the public consultation the EIA report is revised and used when the Greenland Government decides on the project (Greenland Government, 2011).

The 2014 revision of the Mineral Resources Act introduced a new mechanism for early consultations where terms of references for environmental and social impact studies are subject to public consultation early in the process. This will engage the public in discussions about new industry form an early stage, a strong request from environmental NGOs and others engaged in discussions about new industry in Greenland. The 2014 revisions also establishes a minimum consultation period of 8 weeks to allow for the public to study and discuss EIA reports, prepare consultation input and participate in public meetings. Public meetings are to be held in communities affected by a new industry project.

Public consultations have been widely debated in recent years. In a study about legitimacy in decision making Aaen makes the argument that non-governmental organizations in Greenland are generally small and have few resources to participate in consultation processes (Aaen, 2012). She suggests cooperation and a new partnership between NGO’s to make up for the lack of resources. Discussing important criteria for information she stresses that information must be accessible,
easy to locate when needed, relevant, understandable, easy to access without high costs and factual (Aaen, 2012).

Greenland Government has addressed problems with access, establishing a website where all EIA reports and consultation letters are published. Internet is widely distributed in Greenland so most people will have access, but download costs are high. Furthermore language is often a challenge as many companies have English as their corporate language, while Greenlandic and Danish are used by the general public. Greenland Government enforces that reports must be available in Greenlandic to make sure that the entire population can participate in consultations and debates about the project.

Another challenge is with understanding what EIA and social impact assessment reports conclude. The balance between very short summaries and 600 page reports is still to be found. This is also related to the speed at which Greenland is developing these years. In only 10 years, the number of licenses issued or pending Government approval went up from 20 to 100 (Greenland Government, 2013). As a result, some have begun to question the speed at which projects are developed and the number of consultation processes one can fit into a year without public interest and debate suffering (ICC Greenland and WWF-DK, 2013).

Others have questioned the effects of consultations on the final projects. The argument is made, that often EIA consultations take place late in the process where the applicant may well be planning activities for the short Arctic field season. As an example Greenpeace and others were questioning the Cairn Energy trial drilling consultation process, as it was documented that a rig was already on its way across the Atlantic to Greenland when the consultation was started.

Early consultation is requested by several NGO's in Greenland, including Nuup Kangerluata Ikingutai/Friends of the Nuuk Fjord, an organization started to protest plans to establish a large-scale iron ore mine in Nuuk Fjord. Initiator Pîtânguak' Tittussen has asked that the general public be informed about plans for new industry as they develop and consulted in the early scoping processes determining which are the most critical issues to study rather than in the late stages where comprehensive impact assessments have been prepared (ICC Greenland and WWF-DK, 2013).

As a consequence of the widespread criticism of late consultations Premier Hammond and Minister Kirkegaard have both expressed that transparent and public debates with many stakeholders involved are important. Recommendations for activities that will improve consultations have been made (Greenland Government, May 2013). Among the recommendations are early involvement of local communities affected by a project, that consultation periods allow the public 8 weeks to study EIA reports and that consultation meetings will be organized as more dialogue based, e.g. panel debates, round tables etc., and be led by an independent facilitator to allow for more dialogue (Greenland Government, May 2013).
3.3 Current licenses

To provide an overview of all license areas the below map is updated frequently by the Greenland Government (figure 13). Red areas are areas under application where information about the applicant is generally not available.

Greenland Government, Mineral License and Safety Authority (previously Bureau of Minerals and Petroleum), keeps an updated list of licenses granted for mineral and hydrocarbon resources activities. From the November 1 2013 list it was clear that 22 mineral prospecting licenses (non-exclusive) (category IV) and 77 mineral exploration licenses (exclusive) (category II) have been issued. Three licenses for prospecting and 9 licenses for exploration have been issued for areas that are relevant to the Greenland LIA project.

Figure 13 Exclusive licenses September 2013. Retrieved from www.bmp.gl in November 2013

By October 24 2013 the Greenland Government announced that it had granted London Mining Greenland A/S a license to mine iron ore in the Nuuk Fjord region. This was the fifth mineral exploitation license (exclusive) (category III) granted. Licensees that can mine in Greenland right now are therefore Angle Mining (Gold), Minelco A/S, Black Angel Mining A/S, Malmbjerget Molybdenum A/S and London Mining Greenland A/S. No licenses for mining in the Greenland LIA have been granted yet, and as of November 2013 none of the five licenses are used for active mining.

Two new license categories: small-scale licenses for minerals (exclusive) (category VII) and small-scale licenses for minerals (non-exclusive) (category VIII) were established with the last revision of the Mineral Resources act. So far 13 licenses have been issued, all in West Greenland.

By November 1 2013 petroleum prospecting licenses (non-exclusive) (category VI) covered 18 licenses, and five of these are for activities in North and East Greenland. Licensees include TGS-NOPEC Geophysical Company ASA, GX Technology Corp., Norwegian Energy Company ASA and Statoil Greenland A/S. All license periods are four years (expire in 2013-2016).

Petroleum exploration and exploitation licenses (exclusive) (category V) include 19 licenses and of them seven are for activities in North West Greenland off the Melville Bay (License no. 2011/11 – 2011/17).

In December 2013, the Greenland Government decided to grant exploration and exploitation licenses for three consortiums following the 2012/2013 licensing round for the Greenland Sea. The licenses covered four blocks of the 19 blocks offered in two successive licensing rounds Statoil, ConocoPhillips and Nunaoil were awarded an exclusive license for block Avinngaq, ENI, BP, DONG and Nunaoil an exclusive license for block Amaroq, and Chevron, GreenPex, Shell and Nunaoil exclusive licenses for blocks Umimmak and Nerleq (Grønlands Selvstyre, 2013).

Currently 23 applications are being processed. Of these 2 applications (license no. 2014/15 and no. 2014/18) are for activities in North Greenland. Information about the licensee and the deposits/resources explored are confidential until licenses have been granted.

**Territory north of 81° N**

Since February 2012 an area north of 81° N has been closed temporarily for mineral applications (figure 13, grey area). On the Greenland Government website, there is information that new license terms are being developed for the area which contains some of the biggest known zinc deposits in Greenland. The Mineral License and Safety Authority are developing terms that ‘will make it even more attractive to explore the potential of North Greenland’ (BMP website). A
package containing the new terms, a new design of license blocks, data for the area and a time table for opening the area was to be published in 2012.

By May 2014, the Greenland Government will invite new applications for the territory north of 81° N (Grønlands Selvstyre, 2013). In the draft strategy for mineral and hydrocarbon development in Greenland 2014 – 2018 the Ministry for Industry and Mineral Resources announce that licenses will be offered for longer periods of time and that exploration activity obligations may be less strictly enforce.

More relevant in relation to the Greenland LIA is the draft strategy language on potential no-go zones: ‘the region will be subject to a series of independent assessments by which experts will identify particularly vulnerable areas that may be negatively affected by exploration activities. As part of this process areas where licenses for exploration activities cannot be granted will be identified’ (WWF-DK translation), (Greenland Government, 2013).

Applications pending decision, including the Ironbark application for the Citronen Fjord project, have not been effected by then lengthy closure of the territory north of 81° N.
4. Greenland LIA mineral resources

Focusing on the Greenland LIA, the mineral occurrences include iron, copper, zinc, lead, gold and titanium as well as wolfram and barite. This is not an inclusive list of mineral occurrences in the Greenland LIA, but an overview representing the most important occurrences known and the resources where exploration activities are either ongoing or most likely to develop within the next years.

Figure 14 Mineral occurrences map, GEUS. From GEUS factsheet (19/2009) Map of geological environments and selected mineral occurrences. Retrieved from the GEUS website.
**Resources and reserves**
Prospecling and exploration activities are initiated to establish and improve knowledge of resource occurrence, moving from right to left (figure 14). Research and sampling on site is used to establish the grade (quality), the size of the resource (tons) as well as other characteristics of the resource.

**Fact box: establishing resources and reserves.**

Discussing emerging industry one needs to differentiate between mineral resources and mineral reserves. In short, mineral resource is a geological term, while mineral reserve is an economic term.

A mineral reserve is the economically mineable part of a mineral resource.

The mineral reserve is the portion of a resource that can be profitably mined. This makes the reserve a dynamic feature. An increase in the world market’s demand for titanium may move an identified yet not profitable resource into a reserve that can be mined. This would be indicated by a move from the dark grey to the blue area. New technologies replacing the use of titanium in industries could, in contrast, move an economically viable reserve into a resource, moving from blue to dark grey. In the simple model, mining of this reserve would end. But history has provided
examples of mining mineral resources for political reasons, e.g. securing national supply or for keeping jobs.

Mining companies investing in exploration of a license area are driven by an interest to explore a resource that can develop into a mineable reserve. A new mine can be opened or an old mine re-opened with the use of new technologies improving the profitability of operations. An example is the plan to re-open the Black Angel mine in Greenland.

But care must be taken when comparing estimates of resources and reserves. Mining companies will have an interest in announcing large reserves to attract new investors. But the reserve will depend on other factors than the resource – the tons of ore that can be found and the grade of the minerals – mostly on world market prices guided by supply and demand.

Generally the conversion of resources into reserves requires the application of a range of factors besides the geological and metallurgical factors, including economic, environmental, marketing, legal and political and social factors. Many factors are subject to negotiations with government, including negotiations on environmental and social impacts of operations and mitigation efforts to be implemented.

A general rule of thumb used by Greenlandic politicians is that the road from deposit to a mineable reserve is long and bumpy. Then Premier Kleist explained in a debate about the Greenland rush for resources that ‘of 10,000 deposits only 100 are subject to prospecting and exploration activities. And of these only 1 is later developed into a mine’ (January 2013).
4.1 Zinc (Zn) and lead (Pb)

Base metal occurrences in the Greenland LIA include zinc, lead, copper and iron. Prospecting and exploration activities in the Greenland LIA have primarily been targeting these metals, making available resources estimates and grades.

The Geological Survey of Denmark and Greenland (GEUS) has prepared a compilation of all data available on zinc mineralization in North Greenland. Selected zinc occurrences within the Greenland LIA include showings at Cass Fjord, Petermann Prospect, Kap Schuchert on Washington Land, Navarana Fjord on Freuchen Land, Kayser Bjerg on Hall Land, and Hand Bugt and Repulse Havn on Nyboe Land (GEUS, 2012).

To date limited exploration for zinc has been carried out in Greenland, and only a few occurrences have been investigated in enough detail to allow for estimates of the overall resource. But the number of exploration licenses linked to zinc and lead potentials is an indicator of large zinc and lead mineralization in the Franklinian Basin.

Active exploration licenses for Washington Land (2011/32 and 2011/39) have also documented deposits of lead, zinc and silver but no information about the estimated resource, grade and tonnage is available.

Citronen Fjord /Ironbark Zinc (license no. 2007/31, 2010/47 and 2011/33)

The only zinc resource within the Greenland LIA that has been fully investigated is the Citronen Fjord zinc and lead deposit. Prospecting and exploration activities have taken place since 1993, first by Platinova Ltd., to establish the resource and explore opportunities for mining here.

Early estimates were at 27 Mt. But Ironbark Ltd. announced new estimates (Ironbark, 2012):

- A larger resource had been estimated at 132.0 Mt (grade 4.0 pct. zinc and 0.4 pct. lead). The resources estimated is based on 43.1 Mt measured, 51.2 Mt indicated and 37.7 Mt inferred.

- Within this resource a medium grade resource of 70.8 Mt (grade 5.1 pct. zinc and 0.5 pct. lead) is found.

Ironbark Zinc holds three exploration licenses (2007/31, 2010/47 and 2011/33) for an area of approx. 1,000 square kilometers in the Citronen Fjord region. Bedford (no. 3) Ltd., registered in Australia, holds a minerals exploration license for the 2007/02 site, a 120 square kilometer area bordering the Ironbark project. The license will expire by the end of 2016. No information on exploration activities at this site can be found online.
Greenland Government announced that the Citronen fjord resource is one of the world’s largest zinc resources established. Ironbark is preparing an application for exploitation of zinc with an annual production of 250,000 tons of zinc concentrate and 30,000 tons of lead concentrate per annum and a project period of 16 years. A feasibility report for the project establishes that capital costs are USD 429 million, covering the costs of establishing a processing plant, key infrastructure like harbor and housing facilities as well as tailings storage facilities. The mine will be in operation for 14 years and will return revenues of USD 5.65 billion (Ironbark Zinc Ltd. 2013). Favorable characteristics include a site adjacent to deep and protected waters close to both the European and North American markets, simple, flat and continuous ore zones and favorable market conditions as scheduled zinc mine closures may well push up the world market price for zinc.

It is not clear if financing for the project has been secured, but from the company website it reads that Ironbark is working with China Nonferrous under a MOU to deliver fixed price contract and financing for the project (Ironbark Zinc Ltd. 2013).

Here as with other mining projects the relevant question is how much Greenland will gain from allowing foreign investors to mine its resource, e.g. in job creation, tax incomes. For construction 1,000 workers are needed, but most likely these will be foreigners as there are few unemployed construction workers available in Greenland. A permanent staff of up to 300 miners will be needed in the mine, but as no communities are found in the region the mine must be operated on a fly-in fly-out schedule with miners living in barracks.

Preparation for the application process started in 2012 and the Greenland Government has announced that an application is expected in 2014 (Greenland Government, 2013). Ironbark has
prepared environmental baseline studies and a draft EIA for the project. Before public consultations a social impact assessment must be prepared.

Prospecting and exploration activities have documented zinc mineralization in other parts of the LIA, including the license area held by NunaMinerals A/S for exploration activities on Inglefield Land (see section 4.2 below).


Ironbark Zinc Ltd. holds the license for a 112 square kilometer area on Washington Land adjacent to a larger area held by Avannaa Exploration Ltd (see figure 17 below). Interest was first established in 1999 and prospecting has documented mineralization of zinc, lead and barium. Ironbark Zinc Ltd. started exploration activities in 2011 and drillings have documented that Washington Land has the potential to host large scale base metal resources. One drilling documented 16.4 pct. zinc and lead as well as 77 g/t silver (Ironbark Zinc Ltd.).

**Navarana Fjord**

The Geological Survey of Denmark and Greenland (GEUS) report showings of zinc, lead and barite near Navarana Fjord, Feuchen Land and Lauge Koch Land region within the National Park of North and East Greenland. Information available on the internet indicates that only limited prospecting has taken place and no information on the resources can be found. But Ironbark Zinc Ltd. has documented an interest in the occurrences indicated by a 2007 newsletter (Ironbark, 2007).
4.2 Copper (Cu)

Prospecting for copper may be fruitful for J. C. Christensen Land in North East Greenland and Inglefield Land, bordering with Kane Basin and Nares Strait, may have copper and gold mineralization. Exploration licenses for Inglefield Land have been issued and there is interest to explore resources at J. C. Christensen Land.

Inglefield Land/ NunaMinerals A/S (2007/53) and (2013/17)

NunaMinerals A/S is the national minerals exploration company in Greenland. The objective of the company is to develop and utilize Greenland’s natural mineral resources on a commercial basis with the objective of building a profitable business with income from co-ownership of mines, royalties from mining operations and sales of projects. The three largest shareholders are the Greenland Government, Den Professionelle Forening LD, a Danish investment cooperation, and Danish Nykredit Bank.

Nuna Minerals A/S has a wide range of prospecting and exploration activities across the country. Established in 1999 the company has build up a broad project portfolio, including core projects focused on gold and copper; Vagar Gold project, the Storeø gold project and the Inglefield copper-gold prospect which makes NunaMinerals the leading gold exploration company in Greenland. In addition, NunaMinerals has outlined a number of partner projects, including the Qeqertassaq rare earth property, the Ymer tungsten-antimony-gold project, the Amikoq platinum project and the Qaamasoq diamond project. In September 2012, NunaMinerals and KORES, a major state-owned Korean company, announced the signing of a Memorandum of Understanding that could result in the cooperative joint venture of a number of mineral projects (NunaMinerals, newsletter, January 2013).

In total NunaMinerals A/S holds exclusive exploration licenses for an area covering approx. 8,500 square kilometers.

In the Greenland LIA, NunaMinerals A/S has two adjacent license areas: license no. 2007/53 for a 41 square kilometer area and a large area of 5096 square kilometers under license no. 2013/17. The license period is 2012-2016 and 2013-2018 respectively. Both licenses are on Inglefield Land bordering with Kane Basin, an important habitat for polar bears.

Currently, NunaMinerals A/S focuses exploration activities in the Greenland LIA on potentials for copper, gold and zinc in the eastern parts of the license area. But from the company’s project website it is clear that the Inglefield Land has potentials for multiple mineral exploration activities (from NunaMinerals, project Inglefield Land website):

- Early stage exploration for copper (Cu) and gold (Au) near an area named Minturn. Old samples from the area document up to 1.28 pct. copper and 15.6 g/t gold.
• The Inglefield Land license contains a cluster of the highest stream sediment zinc anomalies in North Greenland. The NunaMinerals A/S website does not give information about resource estimates, but the potential resource is compared to the large occurrences of zinc and lead found at Black Angel Mine.

• Inglefield Land is also prospective for cobalt-type nickel-cobalt-gold-silver mineralization. In the west of Inglefield grades of 8.8 pct. cobalt (Co), 7.6 pct. nickel (Ni), 15.6 ppm gold (Au) and 14.9 ppm silver (Ag). The area has basic sills similar in age and composition to the Nipissing diabase at Cobalt, Ontario, Canada.

• Inglefield Land is prospective for diamonds, but currently there is not sufficient evidence for stand-alone diamond exploration. But NunaMinerals has identified higher priority areas for diamond exploration, and diamond exploration is integrated into field campaigns for other mineral resources.

• Sediment samples show anomalies of Rare Earth Elements (REE). At five sites samples had between 1.000 – 3.920 ppm REE.

Figure 16 Exploration licenses, Inglefield Land region, NW Greenland. Retrieved from Nunagis.gl platform.
Washington Land/ Avannaa Exploration Ltd. (2011/39)

Washington Land, a large peninsula bordering with the Greenland Ice Sheet and Kane Basin to the west and the Petermann Glacier and the National Park of North and East Greenland to the east, has mineralization of zinc (Zn), lead (Pb) and silver (Ag) (GEUS, 1997).

Currently, there are two active licenses for Washington Land; the relatively small license area 2011/32 held by Ironbark Zinc Ltd. (see section 4.1) and the 6.159 square kilometre license area held by Avannaa Exploration Ltd. (2011/39). The license expires in 2013. Mineralisation on Washington Land is directly analogous to the Polaris deposit in Nunavut, Canada, where a reserve of 23 million tons at zinc grade of 14.1 pct. was mined (Avannaa Resources Ltd.)

Avannaa Exploration Ltd. is an affiliate of Avannaa Resources Ltd. operating in Greenland only. Established in 2006, the exploration company has a project portfolio focused on base metals copper, lead and zinc, as well as resources of REE and diamonds. Avannaa Exploration Ltd. holds three prospecting licenses and nine exclusive exploration licenses covering an area of 11,488 square kilometers. The largest license area is for one of two known mineralizations in Washington Land; the Petermann Prospect (company website, 2013).

Discovered by the Geological Survey of Denmark and Greenland (GEUS) in 1997 using helicopter reconnaissance, initial sampling demonstrated the presence of high grade zinc and lead mineralization. More recently work document that the Petermann prospect follows a 7 km long complex fault zone which is part of a more than 70 km long system that can be traced across most of Washington Land. Only the easternmost 20 km have been explored to date, but samples have returned grades of up to 42 pct. zinc (Avannaa Resources).

No resource estimates are publicly available, and the company website has no information about prospecting and exploration activities taking place in the 2013 field season.
Avanna Exploration Ltd. previously held licenses for prospecting or exploration on J. C. Christensen Land /Mylius-Erichsen Land in the National Park area. The target resource was copper deposits. But the licenses are no longer active and we have not been able to find information about resource grade and tonnage.
4.3 Iron (Fe)

The southern part of the Qaanaaq region hosts a Neoarchaean iron province, which spatially is the largest in Greenland. It forms a belt traceable for more than 400 kilometers from Kap Seddon in the southeast throughout the Lauge Koch Kyst to Wolstenholme Ø and Carey Øer. This belt correlates with the iron-rich rocks of northern Baffin Island, Canada. Quartz-banded iron formations occur in units of varying thickness, from less than a meter and up to 40 meters, where iron concentrations are typically 30 – 35 pct (GEUS, 2006). A similar occurrence in the northern Baffin Island of Nunavut, Canada, the Mary River iron ore project, has been explored with plans to start mining in 2015.

Melville Bugt / NAMA (2011/25)

North Atlantic Mining Associates (NAMA) Greenland Ltd. (2011/25) has an exploration license for an area of 1,570 square kilometers in the southern Qaanaaq region. The license period is 2011-2015 and exploration activities are focused on deposits of banded iron formations (BIF). Red Rock Resources Ltd., which has projects in Kenya and Columbia too, owns 60 per cent of NAMA Greenland Ltd.

The target minerals for NAMA Greenland Ltd. are high grade DSO iron ore, magnetic iron ore, meso-thermal gold and rare earth elements (REE).

In the summer 2011 mapping, reconnaissance and sampling alongside airborne magnetic and radiometric surveys led to the identification of six key exposed targets and a further five buried magnetic anomalies. Samples highlighted thick zones of massive haematite grading up to 69.4 pct. Fe in the De Dødes East target, and according to the company, the area is a priority target for future drill programs. In 2012 a base camp was established and a diamond drill programme, field work and mapping were conducted to bring more information. These activities confirmed significant thicknesses of haematite-BFI at two targets.

The estimated resource is\(^{10}\):

- 67 million tons magnetite at 31.4 pct. Fe (iron) with 51.2 pct. SO\(_2\) (silicon dioxide) 1.01 pct. AL\(_2\)O\(_3\) (aluminum oxide) and 0.06 pct. P (phosphor) declared for the Havik project (JORC inferred mineral resource estimate).
- Test work from Havik samples show a high quality concentrate with mass recovery of approx. 40 pct. for a concentrate grading at approx. 70 pct. iron (Fe), 2.0 pct. silicon dioxide (S\(_2\)O\(_3\)), 0.3 pct. aluminum oxide (AL\(_2\)O\(_3\)) and 0.01 pct. phosphor (P).
- In addition, twelve exploration targets have been identified with a potential tonnage of between 158 – 474 mt. grading between 27 pct. and 47 pct. Fe (iron).

• In the eastern license area there is a potential for high grade haematite (direct shipping ore) with grades in excess of 60 pct. Fe.

The status of the project is currently unknown. The Red Rock Resources website has no information about exploration activities in the 2013 field season, but from the information available it seems like there is a need for more resources to develop the project into a mine. In November 2012, Red Rock Resources received an offer from a potential partner, but there is no information available on a new project partnership.

**Pituffik / Hunter Minerals (2010/22)**
Hunter Minerals Pty Ltd. has an exploration license for a small area of 25 square kilometers south of Moriusaq. The license expires by the end of 2014.

No information about the deposits explored, but the area has occurrences of titanium, vanadium and iron.

Hunter Minerals Pty Ltd. works with another cooperation, West Melville Metals Inc., to establish resources for iron, titanium and vanadium as part of the Isortoq prospecting project in South Greenland.

*Figure 20* Exploration licenses for the Moriusaq-Savissivik region, NW Greenland. Retrieved from Nunagis.gl platform.
4.4 Nickel (Ni) and Cobalt (Co)

Inglefield Land is also prospective for cobalt-type nickel-cobalt-gold-silver mineralization. In the west of Inglefield grades of 8.8 pct. cobalt (Co) and 7.6 pct. nickel (Ni) have been found in samples also documenting occurrences of silver and gold. There is no estimate of the resource available online, but it must be noted that the area has a basic sill similar in age and composition to the Nipissing diabase at Cobalt, Ontario, Canada.

Cobalt is found in alloys of natural meteoric iron. The free element, produced by smelting, is a hard silver-grey metal. Today most cobalt is a by-product of copper and nickel mining.

4.5 Silver (Ag) and Gold (Au)

The Greenland LIA has occurrences of silver and gold. Information about other precious elements in the Greenland LIA is not available, but Greenland has occurrences of palladium (Pd) and platinum (Pt) too.

Occurrences of silver have been documented on Washington Land in the Greenland LIA. Exploration activities conducted by Ironbark Zinc Ltd. and Avannaa Exploration Ltd. have returned samples with base metals zinc and lead as well as silver. One sample from drillings documented 77 g/t silver (Ironbark Zinc Ltd.).

Geological surveys and prospecting indicate that Inglefield Land, bordering with Kane Basin, is also prospective for silver mineralizations in combination with cobalt, nickel and gold. NunaMinerals A/S has samples from the Minturn area (license no. 2007/53 and 2013/17) that returned 15.6 g/t gold. Samples from the western regions of Inglefield Land returned 14.9 ppm silver.
According to the NunaMinerals A/S website, the targeted resources in the Inglefield Land project are copper, gold and zinc.

4.6 Potentials for specialty metals and gemstones

The Greenland LIA has occurrences of a number of specialty metals, including rare earth elements (REE), titanium, vanadium and barite. Currently, no exploration activities seem to be targeting specialty metals alone and information on grades and potential resources is limited.

Rare Earth Elements (REE)

Rare earth elements (REE) are a set of seventeen chemical elements, specifically the fifteen contiguous lanthanoids plus the lighter scandium and yttrium. Most REEs are not rare. However, because of their geochemical properties, REE are typically dispersed and not often found in concentrated and economically exploitable forms. Often found together REES can be difficult to separate.

While exploration activities have been focused on REE resources in South Greenland - Tanbreeze Greenland Mining A/S exploring the multi-element deposit in Killavaat Alannguat/Kringlerne and Greenland Minerals and Energy A/S developing the nearby Kuannarsuit/Kvaneffield project to mine REE and uranium – NunaMinerals A/S prospecting on Inglefield Land has documented occurrences of REE in the very north region of the country.

On their website for Project Inglefield Land NunaMinerals A/S share a map indicating samples returning REE (figure 21). Of a large number of samples 11 returned grades between 1.000 and 3.920 ppm. REE, while 21 samples returned grades between 500 and 1.000 ppm. REE.
From information available it is difficult to establish if the resource will be economically mineable, e.g. if samples return heavy REE at grades and in quantities large enough to maybe one day allow it to be developed into a reserve.

**Titanium (Ti) and vanadium (V)**

In the western parts of the Greenland LIA, near the settlement of Moriusaq occurrences of titanium and vanadium are found in connection with iron. In the area both Hunter Minerals Pty. Ltd. and NAMA Greenland Ltd. have conducted exploration activities, but there is no information available about reserves of titanium and vanadium.

**Barite**

The Geological Survey of Denmark and Greenland (GEUS) has documented occurrences of barite and zinc in the Navarana fjord region. There is no information available that indicates that prospecting and exploration activities have taken place here.

**Diamonds**

Inglefield Land is prospective for diamonds but currently there is not sufficient evidence for stand-alone diamond exploration. NunaMinerals has identified higher priority areas for diamond exploration, and diamond exploration is integrated into field campaigns for other mineral resources.
4.7 Scenarios for mining operations

The Greenland LIA has the potential to host a range of mining activities, but currently the only advanced resource within the region is the Citronenfjord project. Being one of the world’s largest resources of zinc and lead, the Australian company Ironbark Zinc Ltd. finds the resource economically feasible to mine even if initial capital costs exceed USD 420 million and even if operations will be challenged by harsh weather conditions, sea ice etc. According to the Greenland Government, Ironbark Zinc Ltd. is preparing to hand in an application for mining activities in 2014 (Greenland Government, 2013).

Other prospects and explorations of mineral resources in the Greenland LIA are at early stages and it is difficult to assess if these occurrences and resources will be developed into mineable reserves. Much will depend on negotiations with the Greenland Government, including negotiations on the environmental and social impacts of operations and mitigation efforts to be implemented, while other aspects are external, e.g. the world market supply and demand for these resources.
5. Greenland LIA hydrocarbon resources

In 2008, the U.S. Geological Survey (USGS) published the first petroleum resource estimate for the entire area north of the Arctic Circle. The study was part of a project to assess the global petroleum basins using a standardized and consistent methodology, allowing for comparisons between petroleum basins across the globe.

In short, the conclusion is that the area north of the Arctic Circle has an estimated 90 billion barrels of undiscovered, technically recoverable oil, 1,670 trillion cubic feet of technically recoverable natural gas, and 44 billion barrels of technically recoverable natural gas liquids in 25 geologically defined areas thought to have potential for petroleum (USGS, 2008). Technically recoverable resources are those producible using currently available technologies and practices, indicating that estimates can be changed with new technologies.

The undiscovered resources of the Arctic accounts for about 22 pct. of global resources (13 pct. of the world's undiscovered oil reserves, and 30 pct. of the world's undiscovered natural gas reserves) (USGS, 2008).

Of the estimated totals, more than half of the undiscovered oil resources are estimated to occur in just three geological provinces: in Arctic Alaska, the Amarasia Basin and the East Greenland Rift Basins. And for natural gas more than 70 pct. of the undiscovered natural gas resources are estimated to occur in three provinces; the West Siberian Basin, the East Barents Basins and Arctic Alaska (USGS, 2008). This assessment of likely undiscovered resources is not undisputed, as some authors point out, the Arctic is still largely unknown territory, and others have questioned whether hydrocarbon resources will be found in large enough pools to make exploitation economic (Bishop, 2010).

Allocating the estimated resources to the nearest country, Russia is estimated to hold more than half of the total Arctic resources, while the largest oil resources are found in Alaska, US. Eleven pct. of the 412 billion barrels of oil equivalents are estimated to be found in Greenland. By comparison, 52 pct. was estimated to be found in Russia, 20 pct. in USA, 12 pct. in Norway and 5 pct. in Canada (Ernst & Young). Off these resources 84 pct. is expected to be found off-shore and 67 pct. of the total was natural gas (Ernst & Young).
The Arctic does hold a large proportion of the world’s undiscovered oil and gas resources. Even if the resources can sometimes be described as both high-cost and high-risk resources they are increasingly commercially exploitable as world market demand pushes prices up. Other forces work to depress world market prices, e.g. fracking technologies that releases lower cost hydrocarbons to the marked and the push for renewable energy sources.

By 2007, exploration for petroleum had already resulted in the discovery of 400 oil and gas fields north of the Arctic Circle, mostly in the West Siberian Basin of Russia and on the North Slope of Alaska.
Sedimentary basins of Greenland

Hydrocarbon potentials are confined to the major Phanerozoic sedimentary basins, notably the large basins offshore West Greenland and East Greenland. Here sediments have been deposited over millions of years in depressions in the earth’s crust. The light blue-green offshore areas indicated on the map are areas with a substantial thickness of sediments (> 3 kilometers).

**Figure 21** Sedimentary basins of Greenland. Section of map published by GEUS (geus.dk).

GEUS has estimated that the total area of sedimentary basins with petroleum prospectively in Greenland exceeds 350,000 square kilometers. Geologists were certain that there was oil to be found in Greenland, but until recently no exploration has been successful. Six offshore and one onshore drilling failed to prove the potential for profitable exploration until Cairn Energy in 2010 was able to document hydrocarbon offshore West Greenland.
5.1 West Greenland - East Canada

The USGS most recent assessment of undiscovered technically recoverable oil and gas resources in the West Greenland - East Canada Province, returned an estimate of 7,275 million barrels of oil, 51,816 billion cubic feet of natural gas and 1,152 million barrels of natural gas liquids (USGS, 2008). The total resource is estimated at 17 million barrels of oil equivalents.

The West Greenland – East Canada Province is a complex region with five assessment units. Of relevance to the Last Ice Area is AU – 1 Eurekan Structures, covering waters between Canada and Greenland north of 76N including the North Water Polynya and the Kane Basin region. For this assessment unit the estimate returned a mean of 1,133 million barrels of oil. The assessment unit AU – 2 Northwest Greenland Rifted Margin by comparison returned an estimate of 2,746 million barrels of oil while the central AU – 4 Baffin Bay Basin gave an estimate of 1,555 million barrels of oil.

Currently, most activities are focused in AU – 2 Northwest Greenland Rifted Margin where estimates for oil are at 2,746 million barrels of oil. This assessment unit covers the Melville Bay area recognized as an important habitat for both polar bear, walrus, narwhal, and beluga. Part of the Melville Bay is protected under the Greenland Nature Protection Act.

![Figure 22](image)

**Figure 22** The West Greenland - East Canada Province covering Baffin bay, Davis Strait, Lancaster Sound, Kane Basin and western parts of Nares Strait. From USGS fact sheet (2008).
Baffin Bay block Qamut / (2011/11)
An exclusive exploration and exploitation license for the northernmost block in Baffin Bay (block no. 2 /Qamut) was granted for ConocoPhillips Global NVW Greenland Ltd., DONG Grønland A/S and Nunaoil A/S. The license block covers a 9,392 square kilometer area north of 75 N. The license expires by the end of December 2020.

The area has a small ice-free open window in August and September, where all seismic activities and drilling operations must be conducted. Another challenge is icebergs drifting southwards, and the companies must use satellite imaging and ice radars as well as visual inspections to detect icebergs in time for the seismic vessels to steer clear.

In the field season of 2012 2D seismic activities took place to gather information about the sea bed structures of the Qamut block. The EIA prepared by ConocoPhillips established that activities would take place nearby and within habitat for marine mammals, including narwhal and beluga. Several consultation replies expressed concern about the consequences of 2D seismic activities on wildlife, noting the fact that the license area overlaps with a narwhal protection zone (NPZ 1), where narwhal gather from early June to mid October and beluga from early October. The Ministry of Fisheries, Hunting and Agriculture noted that the Melville Bay is both an important habitat and an important resource for local hunters, and made recommendations that seismic activities end mid September, that a maximum sound pressure level be set, and that passive acoustic monitoring and wildlife observers be used onboard ships to reduce impacts on marine mammals (Grønlands Selvstyre, May 2012).

![Figure 23](image-url) Baffin Bay licenses for offshore hydrocarbon exploration activities layered with information about key habitat for wildlife. Orange areas are license blocks (2011/11, 2011/12 and 2011/13). Dark blue is polar bear habitat, light blue is narwhal habitat. Map is produced using Nunagis (nunagis.gl).
In 2013 the concern for wildlife in relation to seismic activities was brought forward again when Shell Greenland A/S developed plans to prepare seismic activities in three blocks in Baffin Bay, Anu block (2011/12) to the south of Qamut, and Pitu block (2011/13) to the southwest of Qamut. The company first prepared an EIA and later a supplementary programme that would bring seismic activities 10 kilometers into established narwhal protection zones. These activities would be as close as 40 kilometers to the Melville Bay nature reserve.

In a reply to these supplementary plans the Danish Centre for Environment and Energy and the Greenland Institute of Natural Resources expressed concerns about the consequences for marine mammals in the region. They note the knowledge gap in relation to seismic activities and narwhals, known by both researchers and hunters to be sensitive to noise and disturbances, and express concerns about the cumulative effects of seismic activities in narwhal habitat for now two years in a row. A recommendation for successive monitoring of narwhal in Melville Bay is made (Danish Centre for Environment and Energy & Greenland Institute of Natural Resources, 2013). Concerns were also expressed by WWF-DK and a number of other Environmental NGO’s that participated in the consultation process.

Licensees have not yet publicized plans for exploration activities in the summer field season of 2014.

5.2 East Greenland

The USGS assessment establishes the resource of East Greenland as almost twice the size of the West Greenland-East Canada Province.

The East Greenland Rift Basins Province assessed covers an area of 500,000 square kilometers between 70 – 82°N. The coastal waters of this region are part of the National Park of North and East Greenland.

According to the USGS estimates the East Greenland Rift Basins Province contains approx. 31,400 million barrels of oil equivalents (mean). The resource is broken into 8,901 million barrels of oil, 86,179 billion cubic feet of gas and 8,121 million barrels of natural gas liquids (USGS, 2007).

The East Greenland Rift Basins Province was subdivided into seven geologically distinctive assessment units, the assessment unit North Danmarkshavn Salt Basin being within the Greenland LIA. Of the seven subdivided regions, North Danmarkshavn Salt Basin returned 3,274 barrels of oil, and 7,255 billion cubic feet of gas, but only 570 million barrels of natural gas liquids (USGS, 2007).
The two northernmost regions – North Danmarkshavn Salt Basin and South Danmarkshavn Basin – cover 85 pct. of all estimated oil in the East Greenland Rift Basins Province (USGS, 2007).

Figure 24 East Greenland Rift Basins Province covering seven subdivided assessment units of which five were quantitatively assessed. From USGS fact sheet (USGS, 2007).

**Greenland Sea license round 2012/2013**

In April 2011, the Greenland Government announced the opening of the Greenland Sea for hydrocarbon resource activities. The licensing area – 19 blocks covering an area of 49,949 square kilometres of marine areas between 76 – 79°N – was chosen on the basis of a strategic environmental impact assessment for the region. More than 50,000 line kilometres of data from seismic activities has already been collected from this area.

The Greenland Sea licensing round was designed as a two-phase process, where members of the KANUMAS consortium were given preference in a pre-licensing round ending in December 2012 before an ordinary licensing round ending in October 2013. The KANUMAS consortium consists of oil companies that have already conducted exploration activities in Greenland, including Statoil Hydro, BP, ExxonMobil, Chevron Texaco, Shell, Japan Oil, Gas and Metals National Corporation and Greenland’s national oil exploration company Nunaoil A/S (Greenland Government, 2011).
The Greenland Government received three applications (Greenland Government, 2013). Earlier press releases indicate that the three applications all came in following the pre-licensing round, where 11 blocks were up for bidding. Zero applications came in during the ordinary licensing round for 8 blocks.

Awarding the licenses three key criteria were used: the applicants experience with oil and gas activities, the applicants financial capacity and the applicants health, safety and environment policies and work programmes (Greenland Government, 2013). Detailed information about applications and scores are not available to the public, but all applications were awarded with licenses. In December 2013, the Greenland Government announced that exploration and exploitation licenses had been granted for three consortiums (Grønlands Selvstyre, 2013). The licenses cover four of the 19 blocks offered in the two successive licensing rounds.

- Statoil, ConocoPhillips and Nunaoil was awarded an exclusive license for block 6/Avinngaq
- ENI, BP, DONG and Nunaoil an exclusive license for block 8/Amaroq
- Chevron, GreenPex, Shell and Nunaoil exclusive licenses for block 9/Umimmak and block 14/Nerleg
Figure 25 Exploration and exploitation licenses for hydrocarbons in the Greenland Sea awarded after the 2012/2013 licensing round. The pre-licensing round covered 29,868 km$^2$ (11 blocks: 4, 6, 8, 9, 12, 13, 14, 15, 16, 17 and 18). The ordinary license round covered 20,081 km$^2$ (8 blocks: 1, 2, 3, 5, 7, 10, 11 and 19). Map retrieved from Greenland Government website (www.bmp.gl).

Plans to develop oil and gas in the remote areas of Northeast Greenland have raised concern about safety and the environmental impacts that seismic activities, drillings and potential production will have on nature.

The Greenland Sea covers critical habitat for harp seal, hooded seal, and in the fall large groups of little auks and guillemots migrate through this area. Narwhals are wintering at the edge of the ice while polar bears use the entire range of the pack ice.

Mapping ecologically valuable and sensitive marine areas in relation to increased shipping activities, the Danish National Centre for Environment and Energy identifies four areas in Northeast Greenland as areas that meet the criteria for Particularly Sensitive Sea Areas (PSSAs); the Northeast Water polynya (NØ1) important to sea birds and marine mammals, including walrus, the important Scoresbysund Fjord system (NØ2), Young Sound (NØ3) and large sections of the Greenland Sea (NØ4) (figure 28) (Christensen et al, 2012).

Figure 26 Ecologically valuable and sensitive marine areas in relation to increased shipping activities. Northeast Greenland (Christensen et al, 2012).

For the Greenland Sea, layering data about new license areas, valuable and vulnerable areas and wildlife habitat is not yet available in the Greenland Government GIS platform. But from the information available it is clear that there are marked overlaps between the potential resource development activities and key habitat for marine mammals in the Greenland Sea area. An example is given below (figure 29) documenting polar bear range in East Greenland.
Polar bears are threatened by loss of sea ice and across the Arctic only one of 19 subpopulations had increased (IUCN, Polar Bear Summit 2013). The most recent IUCN data on polar bears still show the East Greenland population as data deficient. WWF believes that there is a need to assess the status and the health of the East Greenland polar bear population prior to adding new stressors from seismic activities and test drillings in the Greenland Sea.
5.3 Lincoln Sea and Arctic Ocean

With the West Greenland – East Canada Province and the East Greenland Rift Basin Province assessed attention is not given to the waters north of Greenland; the Lincoln Sea Basin. In 2006 seismic data proved the existence of a deep sedimentary basin underlying the Lincoln Sea. The basin appears to be comparable in width and depth to the Sverdrup Basin of the Canadian Arctic Islands.

In an article by geologists from the Geological Survey of Canada, the US Geological Survey and the Geological Survey of Denmark and Greenland it is stated that the Lincoln Sea Basin is: ‘likely to be petroliferous and contains risked resources on the order of $1 \times 10^9$ barrels of oil to which comes an equivalent amount of (associated and non-associated) gas’ (Sørensen et al, 2011).

Figure 27 The undiscovered oil resources of the Arctic. USGS / Circum-Arctic Resource Appraisal project. Illustration from the USGS website.
The USGS Circum-Arctic Resource Appraisal (CARA) project also points to the fact that the Lincoln Sea Basin, part of the North Greenland Sheared Margin (NGS), is likely to host hydrocarbon resources. But the estimated resource is small compared to other resources north of the Arctic Circle; with an estimated resource of 3,324 million barrels of oil equivalents, the NGS province is ranked as the 14th largest resource in the Arctic (USGS, 2008).
5.4 Scenarios for hydrocarbon activities

The Greenland LIA core area – the coastal region of North Greenland – is prospective for oil and gas, but the resource is relatively small and the region is still a frontier difficult to assess. The Last Ice Area is an area of persisting summer sea ice, and exploration activities will continue to be challenged by the presence of sea ice.

Today exploration activities are focused on resources outside the Greenland LIA, primarily offshore West Greenland. But the interest of oil exploration companies have moved north along the West Greenland coast and large investments are made in the Baffin Bay region. The Baffin Bay region is well south of the Last Ice Area, but activities may affect vulnerable and important ecosystems as the Melville Bay area and the North Water Polynya, whose ecosystem services are important to settlements in the region.

The large resources estimated for the East Greenland Rift Basins Province are less assessable and the challenge of the pack ice, moving from north to south along the East Greenland coast, is a challenge for activities here.

There is widespread disagreement about the future scenarios for hydrocarbon activities in Greenland and in particular there is disagreement about the speed of this development. In a recent report, the Committee for Greenlandic Mineral Resources to the Benefit of Society conclude that we may, if all goes well, see mineral exploitation activities that will contribute significantly to Greenland’s economy by 2020 or 2025. In contrast, the committee speculates that even if exploration activities continue, we will not see production and export of oil within 20 to 50 years (Udvalget for Samfundsgavnlig udnyttelse af Grønlands naturressourcer, 2014).

The Greenland Government is more optimistic about future development scenarios. In a new strategy for mineral and hydrocarbon development for 2014 to 2018, the vision is to continue to explore opportunities for commercially viable oil production in Greenland. For 2014-2018 the goal is for Greenland to have 3-5 mines open and to have 1-2 offshore drilling projects every second year (Grønlands Selvstyre, 2013). Throughout the strategy, a series of activities are identified that will support these goals.

Based on the resource estimates available for the Greenland territory and based on information about current exploration activities, WWF project that we will continue to see exploration for oil and gas resources into the Baffin Bay region, but that the Greenland Sea region will remain a frontier to be developed. Challenges to Greenland Sea activities are related to limiting uncertainties and bridging existing knowledge gaps about reserves, but also to develop technologies for safe operations under difficult conditions. Finally there are challenges to corporate images when planning operations in remote areas that hold key habitats for a number of iconic Arctic species.
WWF sees the core Greenland Last Ice Area as a more distant frontier for hydrocarbon exploration activities. By 2040 we may see research and exploration activities north of Greenland, but the area is likely to remain a distant third to the West Greenland and East Greenland resources when it comes to exploitation.
6. Discussion: sustainable development

Greenland is a frontier for mining and increasingly for exploration of hydrocarbons. Resources in demand by the world market can be mined from the Greenland bedrock and the large sedimentary basins offshore are prospective for oil and gas.

The Greenland Government has actively marketed the resources to be developed here and the efforts have paid off. Over a ten year period the number of licenses issued for prospecting and exploration activities has increased tenfold, and investments made in prospecting and exploration have seen a dramatic increase. Going back only 10 years, investments in prospecting and exploration were well under DKK 50 million, but since 2007 Greenland has seen average investment rates of DKK 500 million annually (Grønlands selvstyre, 2013). This development is led by the investments made in exploration for hydrocarbons offshore of West Greenland, where Cairn Energy operations alone brought revenues for the Greenland economy of DKK 172 million in 2010 and a record high DKK 311 million in 2011 (Grønlands selvstyre, 2011).

Investments have been focused on the western and southern parts of Greenland, but from the above mapping of licenses and activities it is clear that the Greenland LIA is prospective for mining too. Activities are focused in four sites in the LIA core area: Washington Land, Inglefield Land and Citronen Fjord as well as the Savissivik region south of Qaanaaq.

6.1 Scenarios for development within the Greenland LIA

Building on the information available for this study, only simple scenarios for development of mineral and hydrocarbon resources in the Greenland LIA can be outlined.

Information about occurrences of minerals and knowledge about sedimentary basins within or in the vicinity of the Greenland LIA establishes that there is a potential for new industry development within the region. But moving an estimated resource into a reserve that can be economically mined is also dependent on world market prices. For example, the zinc and lead deposits found in Citronen Fjord may be one of the largest resources known, but the resource may still be marginal and investments few if world market demand is reduced under an economic crisis or if zinc production is increased elsewhere to balance supply with demand.

Focusing on the Greenland LIA, a likely scenario is that we will see mining operations in Citronen Fjord within five to ten years. The Ironbark Zinc Ltd. project is mature and data for an environmental impact assessment has been prepared. Greenland Government expects to receive an application for a license to mine the resource in 2014.
The remaining projects found within the Greenland LIA have not yet matured into projects that are likely to bring new applications for exploitation licenses in the near future. But the region does host mineral occurrences that can be developed into mature projects over the next decade or two. By 2040 it is likely that mining will take place within the Greenland LIA.

In contrast, the above analysis suggests that oil and gas resources development within the core Greenland LIA is unlikely by 2040.

Currently, investments in prospecting and exploration of hydrocarbons are focused primarily on the West Greenland Baffin Bay region, secondly on new license area in the Greenland Sea and offshore South Greenland. Development of the Baffin Bay resources is likely to continue and maybe these activities will result in the first commercial production of oil and gas within Greenland territory. The Greenland Sea – with an estimated resource of 31 million barrels of oil – is likely to be the second region to see increased exploration. But harsh weather and ice conditions, distances and lack of infrastructure makes the Greenland Sea a challenging frontier, where risks are high and where large investments must be made before any production make take place.

By comparison, the estimated resource of the North Greenland Sheared Margin overlapping with parts of the Greenland LIA, is relatively small and challenges related to logistics and safety of operations is numerous.

A parallel analysis assessing the current and future development of minerals and hydrocarbon resources in the Canadian and Greenlandic sections of the Last Ice Area is being prepared by consultant Peter Adams for WWF Global Arctic Programme. The joint analysis will establish scenarios for mineral and hydrocarbon resources activities across the Last Ice Area based on known reserve estimates, the likely costs of developing those reserves, and projections of demand for those resources. Such an analysis will help establish the likely economic viability of extractive industry developments in the LIA.

6.2 Sustainable development of the Greenland LIA

Traditionally, the Greenland LIA has been a region of limited human presence and use. A small population lives in a few communities and from here they have travelled by dog sledge and boat into the Greenland LIA to harvest polar bear, walrus, narwhal and beluga. But increasingly we see new uses of the Greenland LIA.
Layering information about wildlife abundance and traditional human uses with information about exploration for minerals and hydrocarbons, we see a number of areas of overlapping interests and potential conflicts. With areas of overlapping uses and interests there is a need for governance even in remote areas of the country.

Figure 28 Overlapping resources and interests in Melville Bay, Washington Land and Inglefield Land, western Greenland LIA. Licenses for exploration of hydrocarbons and mineral exploration activities layered with data of wildlife habitat and traditional human uses. Map retrieved from Nunagis (nunagis.gl).

Focusing on the western sections of the Greenland LIA the GIS map brings attention to two sites of overlapping uses and interests and therefore potential conflict: The Melville Bay and the Kane Basin/Inglefield Land region (figure 31).

Melville Bay nature reserve was established under the Nature Protection Act to protect important polar bear and narwhal habitat, reducing human disturbances to a minimum, but allowing for traditional harvest. But in 2012 and 2013 seismic activities in adjacent Qamut and Pitu blocks (orange-yellow areas) did conflict with areas with concentrations of narwhal and with local
hunting grounds for beluga (red areas). Both scientific and traditional knowledge has documented that narwhal are vulnerable to disturbances, and concern was expressed with the cumulative effects of seismic activities in the field season of 2012 and 2013 on narwhal distribution (Danish Centre for Environment and Energy & Greenland Institute of Natural Resources, 2013).

The effects of seismic activities on narwhal and other whales are discussed in scientific literature (Heide-Jørgensen et al, 2013) and there is a need for controlled studies of wildlife behaviour following the use of seismic air guns.

Mapping mineral resources activities with wildlife habitat, another area of potential conflict is the Kane Basin/Inglefield Land region. Licenses for exploration activities on Inglefield Land overlap with known polar bear concentrations for the Kane Basin population. The IUCN polar bear status map presented at the Polar Bear Summit 2013 in Moscow, Russia, documents that the small Kane Basin population is reduced. The sub-population of Kane Basin is being re-assessed but experts estimate the population to show a declining trend (IUCN, Polar Bear Specialist Group, website). But sea ice projections show that summer sea ice will remain in this region and the Kane Basin may well be a future important habitat for polar bears. The example of overlapping uses in Melville Bay documents a current need for governance, while the Kane Basin region is an example of projections and scenarios pointing towards a need for future governance.

While there are still gaps in data, research and observations by local users have documented areas that are valuable and sensitive for single species and entire ecosystems. Projections of the likely high ecological and cultural value of resilient ice have also been made by institutions such as the Arctic Council, as well as by conservation organizations. Informed by research and knowledge about current uses and projection for future uses, governance should be developed to secure sustainable development of the Greenland LIA.

### 6.3 Recommendations

WWF recommends that Greenland embarks on a sustainable development path that balances the development of new industry, in particular of mineral resources and oil and gas resources development, with other uses.

WWF recommends the Greenland Government to commit to long-term governance and management plans informed by research in climate change and the effects that climate change will have on Arctic ecosystems, and informed by knowledge about current uses and projects for future uses of the natural resources of Northern Greenland.
More specifically, WWF recommends that the Greenland Government:

- Develop a strategy for the **National Park of North and East Greenland**, building from existing research and knowledge about ecologically and culturally important areas as well as scenarios for climate change.

- Consider new management measures that will secure adaptive management of **resilient summer sea ice between** North Greenland and the Canadian Archipelago. This resilient summer sea ice will become an important habitat for ice-dependent species.

- Develop management measures to protect and conserve the **North Water Polynya**, an open water area acknowledged for its importance to marine mammals and sea birds in the region.

- Consider the introduction of zoning – a flexible management mechanism that protects a core area from human disturbances but allows for some uses in buffer zones and for development outside these zones - in management. Zoning could be introduced in renewed management of **Melville Bay/Qimussersuaq** and in management of **Inglefield Land/Kane Basin**.
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Greenland Government resources


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Appendices

1. GEUS Geological map of Greenland