LLOYD'S

ARCTIC OPENING:

Opportunity and Risk in the High North

60°N

GEOPOLITICS

ECOSYSTEM

EXTREME CLIMATE

-48°C

REPUTATIONAL RISK

CHATHAM HOUSE

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ARCTIC OPENING:

Opportunity and Risk in the High North

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foreword

Those monitoring the effects of climate change agree that the pace of environmental transformation currently taking place in the Arctic is unprecedented. As this report shows, such changes provide opportunities for business in areas as diverse as energy extraction, shipping and tourism. But these opportunities will only be fully realised if the businesses involved are able to manage the substantial, and unique, risks which exist in the region. There will be winners and losers as the impacts of climate change continue to shape the Arctic future.

One thing that stands out most clearly from this report is the significant level of uncertainty about the Arctic's future, both environmentally and economically. Some of the technologies that will help to shape that future, such as those involved in deep water drilling and ice management are already tried, while others are still in their infancy or yet to be developed.

Risk management clearly has a critical role to play in helping businesses, governments and communities manage these uncertainties and minimise risks. However, to do so effectively requires the most up to date information to analyse and control risks; there is a clear need for sustained investment in Arctic research.

The 'known-unknowns' of the High North present particular challenges for those involved in exploration and extraction. The Arctic is a frontier unlike any other, and the industries and companies it attracts will need to develop and implement robust risk management systems to meet these challenges and manage both their carbon and environmental footprint on this pristine setting.

The environmental implications of further development of the region are significant, reaching far beyond the immediate Arctic region itself. How, for example, will developments in hydrocarbon exploration and extraction align with commitments to reduce global greenhouse gas emissions and the need to increase our use of renewable energy?

As recent events have shown, deep water exploration can have devastating consequences on local environments. The ability to contain and manage the fall-out from disasters is affected by issues including access, support infrastructure and cross-border political and legal requirements. Given that several states have jurisdiction over different parts of the Arctic, it will become even more important to develop and agree clear governance frameworks to allow effective and co-ordinated responses to disasters.

This report explores how fluctuations in energy prices have driven, and will continue to drive, the pace of exploration in the Arctic and the importance of both political stability and public support in attracting future investment.

The businesses which will succeed will be those which take their responsibilities to the region's communities and environment seriously, working with other stakeholders to manage the wide range of Arctic risks and ensuring that future development is sustainable.

Richard Ward
CEO
Lloyd's

executive summary

- **Rapid and disruptive change in the Arctic environment presents uneven prospects for investment and economic development**
  Environmental changes, especially those linked to global climate change, are giving rise to a broad set of economic and political developments. Sustainable realisation of the economic opportunities that result from these developments depends on strong regulatory frameworks and corporate environmental stewardship. All across the Arctic, changes in climate will create new vulnerabilities for infrastructure and present new design challenges.

- **The Arctic is likely to attract substantial investment over the coming decade, potentially reaching $100bn or more**
  There is a wide range of potential scenarios for the Arctic's economic future, depending principally on local investment conditions and global commodity prices. Oil and gas, mining and the shipping industries will be the biggest drivers and beneficiaries of Arctic economic development. Industries supporting these activities, such as fisheries, aquaculture, tourism and scientific research, could also contribute to the longer-term economic sustainability of Arctic communities. Based on current trends, expected investment in the Arctic could reach $100bn or more over the next decade. However, given the high risk/potentially high reward nature of Arctic investment, this figure could be significantly higher or lower.

- **Significant knowledge gaps across the Arctic need to be closed urgently**
  Uncertainties and knowledge gaps exist around the nature of environmental change, the geological potential of the Arctic and environmental baselines, as well as seabed mapping, and how to deal with the risks of significant Arctic industrial activity. Governments, research institutes, non-governmental organisations and businesses can help close these gaps, as a way of reducing risk and ensuring that development takes place within sensible, defined, ecological limits.

- **Arctic conditions will remain challenging and often unpredictable**
  The Arctic will remain a complex risk environment. Many of the operational risks to Arctic economic development – particularly oil and gas developments, and shipping – amplify one another. At the same time, the resilience of the Arctic's ecosystems to withstand risk events is weak, and political and corporate sensitivity to a disaster is high.

- **The environmental consequences of disasters in the Arctic are likely to be worse than in other regions**
  While particular risk events – such as an oil-spill – are not necessarily more likely in the Arctic than in other extreme environments, the potential environmental consequences, difficulty and cost of clean-up may be significantly greater, with implications for governments, businesses and the insurance industry. Transborder risks, covering several jurisdictions, add further complications.

- **The politics of Arctic economic development are controversial and fluid**
  Given the Arctic's iconic status and sensitive environment, Arctic development is often politically contentious, with sometimes opposing interests and perspectives between local, national and international levels. Political support for development will continue to represent an uncertainty for businesses seeking to invest in Arctic projects.

- **Governance frameworks in the Arctic should continue to develop in their current direction and be reinforced where possible**

  There are major differences between regulatory regimes, standards and governance capacity across the Arctic states. The challenges of Arctic development demand coordinated responses where viable, common standards where possible, transparency and best practice across the north. These frameworks need to be in place to enable sustainable development and uphold the public interest.

- **Risk management is fundamental for companies to work safely, sustainably and successfully in the Arctic**

  Companies operating in the Arctic require robust risk management frameworks and processes that adopt best practice and contain worst case scenarios, crisis response plans and full-scale exercises. There are many practical steps businesses can take to manage risks effectively, including investing in Arctic-specific technologies and implementing best-in-class operational and safety standards, as well as transferring some of the risks to specialist insurers.

introduction: Change, Uncertainty and Risk in the Arctic

The combined effects of global resource depletion, climate change and technological progress mean that the natural resource base of the Arctic is now increasingly significant and commercially viable.

Transformational change

The Arctic region is undergoing unprecedented and disruptive change. Its climate is changing more rapidly than anywhere else on earth. Rising temperatures are causing a retreat of sea ice and changes to seasonal length, weather patterns and ecosystems. These changes have prompted a reassessment of economic and development potential in the Arctic and are giving rise to a set of far-reaching political developments.

Although traditional Arctic products – mostly relating to fishing, sealing, whaling and trapping – have long reached global markets and been influenced by global demands, before the 20th century the overall role and scale of the Arctic in the global economy was minimal [i]. The population of the Arctic – comprising the Arctic areas of Canada, Denmark (Greenland), Finland, Iceland, Sweden, Norway, Russia and the United States – is approximately one-twentieth of one per cent of the world's total population.

The combined effects of global resource depletion, climate change and technological progress mean that the natural resource base of the Arctic – fisheries, minerals and oil and gas – is now increasingly significant and commercially viable. At the same time, economic value is beginning to be attached to the Arctic natural environment, both for its role in regulating global climate and for its biodiversity. This is giving rise to prospecting for commercially viable biological processes and materials[1]. The wind and hydro-power potential of some parts of the Arctic is being explored. The region is attracting a growing number of tourists. Shipping activity has expanded and intercontinental shipping, though several decades from reaching anything approaching the scale of existing major shipping routes, is a developing commercial reality.

Different regional and global economic scenarios suggest a range of possible future trajectories for Arctic development. Key uncertainties over future environmental conditions and the scale and accessibility of Arctic natural resources are compounded by uncertainty about the pace of technological development, the price of hydrocarbons, the future shape and demands of the global economy, and the political choices of Arctic states. Environmental disaster – whether due to a single event, or as a cumulative result of increased economic activity – could rapidly and

[i] Although its mineral wealth was well known, the Arctic only became a significant factor in oil production in the second half of the 20th century, with the development of the Prudhoe Bay field in northern Alaska.

significantly change the Arctic's political and economic dynamics. Still more acutely than elsewhere in the world, economic development and environmental sustainability in the Arctic are co-dependent.

If current patterns continue, however, investment in the Arctic could potentially reach $100bn or more over the next ten years, largely in the development of non-renewable natural resources, and in infrastructure construction and renewal [ii]. For some, this prospect represents a substantial business opportunity. But it also brings a unique and complex set of risks, and raises significant policy dilemmas.

One Arctic, many Arctics

The Arctic can be defined in different ways. Often, the term is taken to refer to the Arctic Ocean alone or, as in the definition of the International Maritime Organisation, a part of it. Sometimes, it denotes both land and sea north of the Arctic Circle (66°N), though Arctic countries themselves often define Arctic areas as being north of 60°. Other delimitations of the Arctic include those determined by temperature or the extent of vegetation. 'Arctic conditions', notably the presence of sea ice and icebergs, can occur in strictly sub-Arctic areas, such as off Sakhalin, in Russia's Far East, or in the Baltic Sea, or off the coast of Newfoundland.

All of these definitions cover a different area of the Northern Hemisphere. This report uses a broad definition of the Arctic, corresponding most closely to that used by the Arctic states themselves. This encompasses land and sea areas north of 60° for the United States, Canada, Russia, Norway, Sweden and Finland, and the whole of Greenland and Iceland.

In the end, however, there is not one Arctic, but many. Environmental conditions, geological prospectivity, physical accessibility, population levels, economic development and political salience all vary. The balance of risk and opportunity for major Arctic development projects depends on a range of further factors:

- For oil and gas developments, there is a key distinction between onshore and offshore developments, between shallow water offshore and deep water offshore, and between developments close to existing pipelines and transport infrastructure and those that would require the construction of entirely new pipelines and infrastructure.

- For Arctic shipping, the widely varying quality of seabed mapping in different parts of the Arctic, and disparities in port infrastructure, surveillance and search and rescue capability, create an uneven matrix of risk and opportunity.

- The Arctic is not – nor is it likely to become – a truly single regulatory space, even while the Arctic Council, Arctic states and other interested parties are increasingly forging common approaches to shared challenges [iii].

End of the frontier?

The Arctic has long been considered a frontier. However, in some places, and for some projects, that is no longer the case. Oil has been produced continuously onshore in the Arctic for several decades. Offshore drilling first took place in the Arctic in the 1970s. Many of the technologies necessary for wider Arctic development are already used in other parts of the world with similar conditions. However, cumulatively, the large-scale development of the Arctic represents a unique and rapidly evolving set of risks. The management of these risks will determine how – and whether – the opportunities of Arctic development are realised.

Comprehensive and rigorous risk management is essential for companies seeking to invest in the Arctic. Those companies that can manage their own risks, using technologies and services most adapted to Arctic conditions, are most likely to be commercially successful. A long-term and comprehensive regulatory approach – incorporating national governments, bodies such as the Arctic Council, and industry bodies – is necessary for effective risk management, mandating cross-Arctic best practices and defining public policy priorities on what constitutes appropriate development.

This current report has three main parts. The first assesses Arctic environmental change, and its immediate prospects and consequences. The second looks at the economic potential of the Arctic, the politics of the Arctic, and critical uncertainties underlying different possible Arctic futures. The third outlines the full range of risks – from both a corporate and a public policy perspective – and assesses a number of potential responses.

[ii] Projections of investment in the Arctic are highly speculative. This figure is based on a conservative assessment of a range of projections and statements from companies, consultancies and the authors' best estimate of likely and unlikely developments. The figure should provide an indication of scale, rather than a definite prediction.

[iii] The Arctic Council is a consultative body comprising the eight Arctic states, a number of non-voting permanent participants (notably, organisations representing the Arctic's indigenous populations), and both permanent and ad hoc observers.

1. Geography Transformed: Environmental Change and the Arctic

From an environmental perspective, there is not one Arctic, but many [2]. Conditions at similar lines of latitude can be starkly different.

On an average day in January, the minimum temperature in Tromsø in northern Norway will be minus 6.7°C [iv]. A little to the south and considerably to the east, in Salekhard, capital of Russia's Yamal-Nenets district and focus of Russia's Arctic natural gas prospects, it will be minus 29.7°C. In Tiksi, on the east Siberian shoreline, it will be colder still: minus 36.7°C. Across the Bering Strait and far inland, the temperature in Fairbanks, Alaska will be minus 28.1°C. It will not be much different in Iqaluit, capital of Canada's Nunavut territory. Meanwhile, in Nuuk, capital of Greenland and part of the kingdom of Denmark, it will be relatively warm: around minus ten degrees.

Figure 1. Map of the Arctic and shipping routes

Source: Adapted from CIA: The World Factbook, https://www.cia.gov/library/publications/the-world-factbook/maps/refmap_arctic.html

[iv] All figures from the World Meteorological Organisation, which in turn depends upon national reporting organisations, which may calculate averages slightly differently. The figures here are described as the mean daily minimum for January and the mean daily maximum for July. Available at: http://worldweather.wmo.int/

Temperatures in July will be similarly varied: from a maximum temperature on an average day of 8.7°C in Tromsø to 22.4°C in Fairbanks. The range from average daily minimum in January to average daily maximum in July is less than 20 degrees in Tromsø, representing a relatively temperate and stable climate. In Salekhard, Tiksi and Fairbanks, the swings between winter and summer are much greater: nearly 50 degrees.

Temperature is only one indicator, and one determinant, of environmental diversity. This diversity is even greater for other conditions: rates of precipitation, the prevalence of sea ice in coastal areas and the presence of permafrost, forest or tundra. Most of Greenland is covered in year-round ice, amounting to approximately 2.85 million cubic kilometres. Most of the rest of land in the Arctic is not.

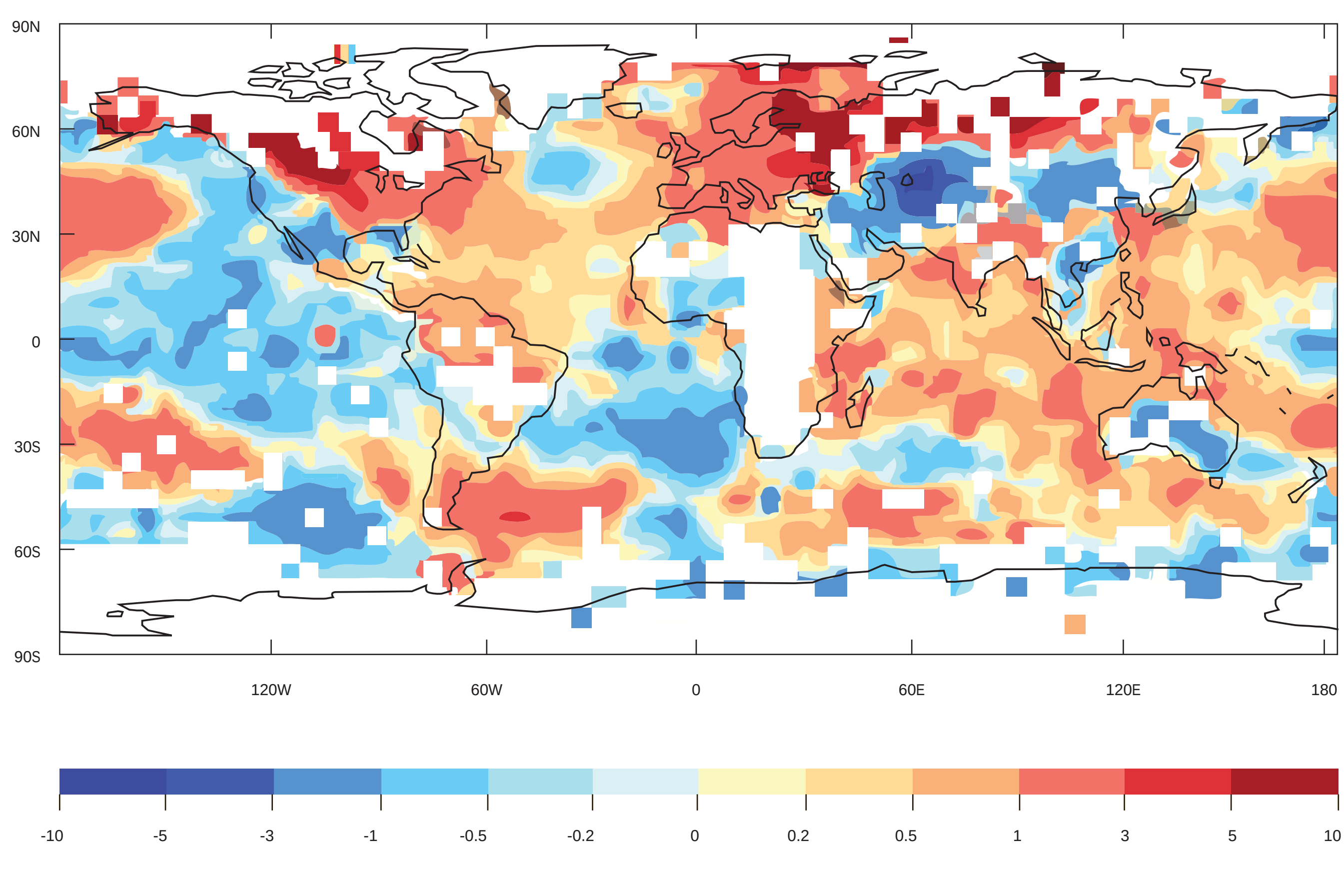
What unites the Arctic, however, is the rate at which it is warming and the speed of change this implies for its natural environment as a whole – transforming the Arctic's geography, ecosystems and how it relates to the rest of the world.

1.1 Arctic Climate Change: Global Early-Warning

The Arctic is not only warming – it is warming more rapidly than anywhere else on earth (see Figure 2) – acting as an early-warning signal for the globe. In 2011, annual near-surface air temperatures over much of the Arctic Ocean were 1.5°C warmer than the 1981–2010 baseline. Against an earlier baseline [3], the differences in temperature, both on land and over water, are greater still. These data points form part of a much longer warming trend [4].

The feedback loops that explain this process are collectively known as 'Arctic amplification'. Reductions in sea ice and snow cover are one factor: as the Arctic becomes less white it absorbs more heat and reflects less. But there are also factors that relate to cloud and wind patterns, themselves affected by broader climate change, and the enhanced movement of moisture and heat from the equator towards the poles.

Figure 2. Surface temperature anomalies compared to 1961-1990 baseline



Source: UK Met Office[5]

To the extent that some global climate change is locked in by current and past greenhouse gas emissions, the Arctic will continue to warm, and warm more quickly than the rest of the world, for the foreseeable future. Success in global climate negotiations under the UNFCCC [v] would not substantially alter that outlook over the next few decades. The Arctic is already undergoing a profound and hard-to-reverse environmental state change.

Temperature changes are reflected in other data. In Barrow, Alaska, 30 June 2011 marked the beginning of a record-breaking run of 86 days where the minimum temperature stayed at or above freezing (the previous record was 68 days in 2009) [6]. All across the Arctic, summers have come earlier and lasted longer. Indigenous peoples who hunt on sea ice have noticed that the ice has become more unpredictable and that the hunting season has become shorter [7].

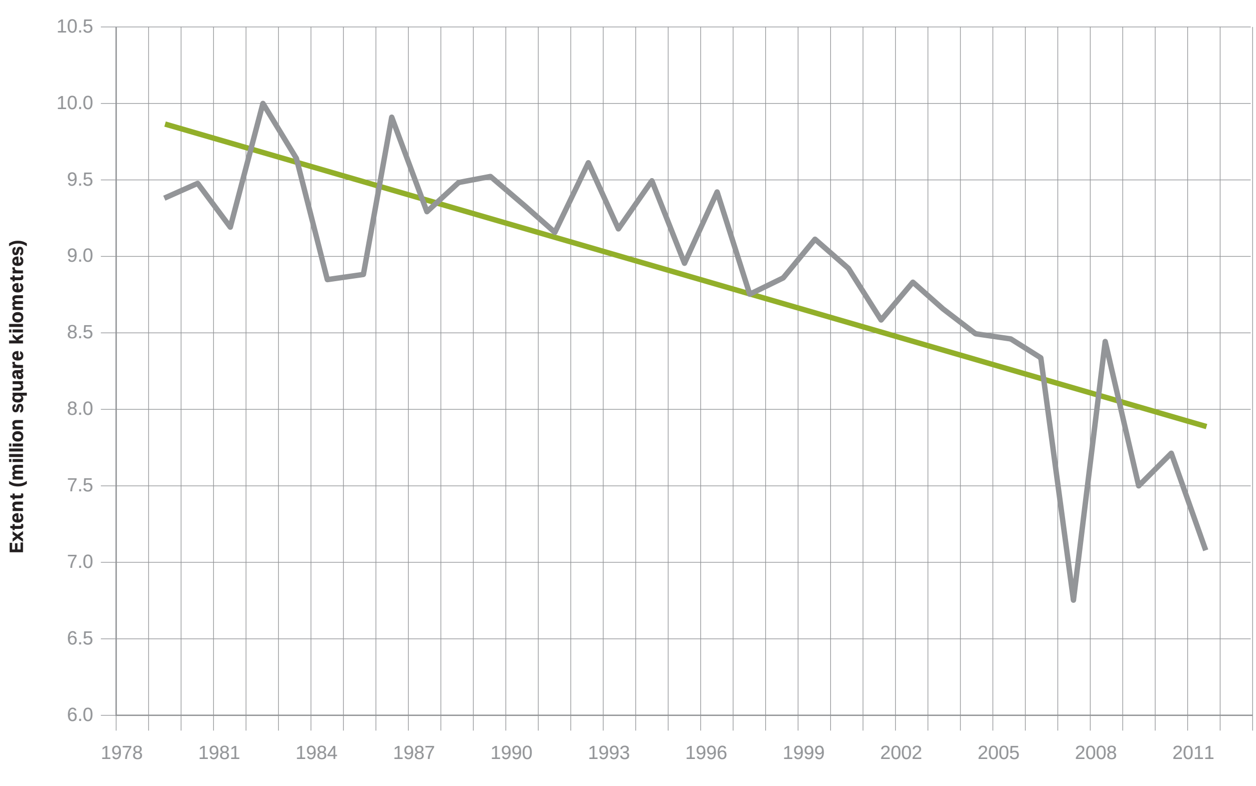
1.2 Sea ice Retreat: More than Meets the Eye

The reduction in the extent of summer sea ice is the most high-profile indicator of Arctic climate change. The processes driving this retreat are complex: sea ice dynamics, air temperature, sea temperature, weather patterns and the physical geography of the Arctic as an ocean enclosed by land all play a part.

Although there is some variability in ice extent from year to year, and although the annual cycle of melting and freezing continues, the overall downward trend in the September sea ice extent, recorded by the US National Snow and Ice Data Center (NSIDC) since 1979, is strong and unambiguous. Historical data from other sources – such as the number of days when particular harbours have been iced up or ice-free, or century-old ice records of scientific expeditions – support the picture of sharply reduced ice extent compared with earlier periods.

In September 2011, the month when Arctic sea ice extent is typically at its lowest, ice coverage fell to a low of 4.33 million square kilometres (1.67 million square miles), some 2.38 million square kilometres less than the 1979–2000 average (see Figure 3) [8]. The NSIDC records show ice extent lower in only one other year – 2007, when it reached 4.17 million square kilometres. Using a slightly different methodology, scientists at the University

Figure 3. Decline in average sea ice extent in September, 1979-2011



Source: National Snow and Ice Data Centre

[v] United Nations Framework Convention on Climate Change.

of Bremen reported that Arctic sea ice extent actually reached a minimum of 4.24 million square kilometres on 8 September 2011 – 27,000 square kilometres below the Bremen team's estimate for summer 2007 [9]. According to their estimates, Arctic sea ice cover last reached this minimum 8,000 years ago.

Dramatic as it is, the reduction in the extent of Arctic sea ice cover is only half the picture. Arctic ice is also both thinner and younger than previously. In the early 1980s, the NSIDC estimated that as much as 40% of Arctic September ice was more than five years old. In 2011, that proportion had declined to 5%. This shift has important ramifications, both climatic (eg the dynamics of the ice cover) and socio-economic (eg the location of multi-year ice has a significant impact on the viability of various Arctic shipping routes).

Estimating ice thickness – and therefore the overall volume of Arctic ice – is more complicated than measuring surface ice extent. Ice thickness varies across the Arctic depending on a range of conditions, and cannot be continuously assessed. Most Arctic ice is constantly moving [vi].

However, the picture built up by a combination of modelling, on- and under-ice data collection from the Arctic and satellite remote sensing suggests that Arctic ice thickness – and volume – is declining even more rapidly than ice extent. The monthly average ice volume estimated in September 2011 was 4,300 km^3, 66% below the mean for 1979–2010 (see Figure 4) [10].

Ice extent, age and thickness are all relevant to the likely future of Arctic sea ice. Recent research suggests that most models have underestimated the importance of these and other factors in predicting the trajectory of Arctic ice extent[12]. Younger and thinner Arctic ice is more prone to melting, and more prone to break-up – including by ships. The formation of sea ice will be affected by a relatively more open Arctic Ocean, as waves tend to become stronger and more frequent [viii]. In short, the less ice there is in one year, the harder it is for ice extent and volume to recover over the winter months. The demise of Arctic sea ice – to the extent of ice-free Arctic summers – could be more abrupt than the trend lines suggest.

Figure 4. Decline in average estimated sea ice volume, 1979-now [vii]

Source: Polar Science Center, University of Washington[11]

[vi] The exception to this is land-fast ice, which is sea ice that has frozen over shallow parts of the continental shelf.

[vii] Shaded areas show one or two standard deviations from the trend. Error bars indicate the uncertainty of the monthly anomaly plotted once per year.
[viii] The enclosure of the Arctic Ocean by the land masses of North America and Eurasia have tended to reduce the fetch of waves, and thereby lead to different sea ice dynamics to those around Antarctica.

box 1: An Ice-free Arctic Ocean?

Projections of the date when the Arctic Ocean will first be free of sea ice in summer have been brought forward in recent years. The 2007 IPCC report suggested that this might occur by the end of the 21st century. Since then the record of actual reductions in sea ice extent have led most scientists to conclude that the first ice-free summer in the Arctic Ocean will be within the next 25 to 40 years, while some claim it could conceivably occur within the next decade [ix]. Reductions in summer sea ice allowing for essentially unimpeded maritime traffic, will occur before the Arctic Ocean becomes fully ice-free in summer.

The Arctic Ocean will continue to freeze up in winter. Ice extent will remain unpredictable, hampering regular traffic without ice-capable vessels and complicating planning for oil and gas exploration. Sea ice will continue to be a challenge to navigation in large parts of the Arctic for much of the year, particularly where broken ice clogs narrow waterways, or where sea ice is flushed out of the Arctic through the Davis and Fram Straits. In some places, climate change may result in an accelerated rate of calving of icebergs from glaciers, which will in turn increase the number and size of icebergs [x]. This is likely to present additional challenges for maritime activity on the sea surface and raise the risk of scouring along the seabed [xi].

1.3 Ecosystems on the edge

As the prevailing environmental conditions in the Arctic change, so do the living ecosystems adapted to those particular conditions.

Some benefit from climate change: at the bottom of the marine food chain primary production by phytoplankton in the Arctic increased by 20% between 1998 and 2009 (and the increase has been as much as 70% in the Kara Sea and 135% in the Siberian sectors of the eastern Arctic Ocean) [13]. On land, the Arctic is becoming increasingly green.

Some lose: walrus and polar bear populations have tended to decline because of reductions in sea ice, while ocean acidification due to increased carbon dioxide uptake in warmer seas can harm some marine life and the fisheries associated with them [14]. Others adapt: some fish stocks have moved, and flourished, as a result of warmer waters. In the short term, cod stocks in the Barents Sea and off the coast of Greenland have become more productive, and have moved further north than ever.

Over time, however, the impacts of climate change – and greater economic development – are more complex than identifying winners and losers. As with sea ice, changes in ecosystems can be discontinuous and abrupt. Marine ecosystems inter-relate in previously unexpected ways. Northward-moving fish stocks inevitably alter the balance in the ecosystem into which they migrate, including out-competing or preying upon established Arctic species [15]. Some invasive species – introduced as a result of greater human activity – can destroy existing ecosystems. Though the impact of increased ocean noise from shipping on those is not clear, it is likely to have a negative impact on marine mammals that use acoustics for prey location and navigation.

At the same time, air- and sea-borne pollution from the industrialised south, such as persistent organic pollutants (POPs), can pose a serious challenge to ecosystems that, in the Arctic, tend to be relatively simple, vulnerable and difficult to re-establish. The increasing rate of disruption to Arctic ecosystems makes their future structure increasingly hard to predict. It also makes establishing environmental baseline data – against which change is measured and potential future changes are assessed – even more important.

1.4 New Access, New Vulnerabilities

Over the next few decades the trend towards more ice-free areas of the Arctic Ocean, and longer ice-free periods, is expected to continue. This will improve sea-borne access

[ix] There is a wide range of projections for when the first ice-free Arctic summer will occur. See, for example, Muyin Wang and James E. Overland, 'A sea ice free summer Arctic within 30 years?', Geophysical Research Letters, Vol. 36, 2009; and Julienne Stroeve, Marika M. Holland, Walt Meier, Ted Scambos and Mark Serreze, 'Arctic sea ice decline: Faster than forecast', Geophysical Research Letters, Vol. 34, 2007. The most aggressive projections suggest this could occur before 2020 (see, for example, Professor Wieslaw Maslowski, Naval Postgraduate School, or Professor Peter Wadhams, University of Cambridge).

[x] Calving occurs when an iceberg breaks off from an ice-shelf (in the Antarctic) or from a glacier as it runs into the sea (for example, off the coast of Greenland).

[xi] Scouring occurs when the bottom of a glacier drags along the seabed. In relatively shallow waters this is potentially a risk for sub-sea infrastructure, such as cables, pipelines and sub-sea oil and gas installations.

to coastal areas that, for parts of the year, are currently either inaccessible or accessible only by heavy icebreakers, which are expensive to build, maintain and charter. The opening of the Arctic will reduce shipping costs where icebreakers are no longer needed, and extend exploration and drilling seasons for offshore oil and gas.

The changes will be most noticeable in areas that are currently most ice-prone, off the coasts of Greenland, Canada and Alaska and particularly along Russia's northern coastline. Areas where sea ice is already less common – such as off the coast of northern Norway – will see a less radical shift.

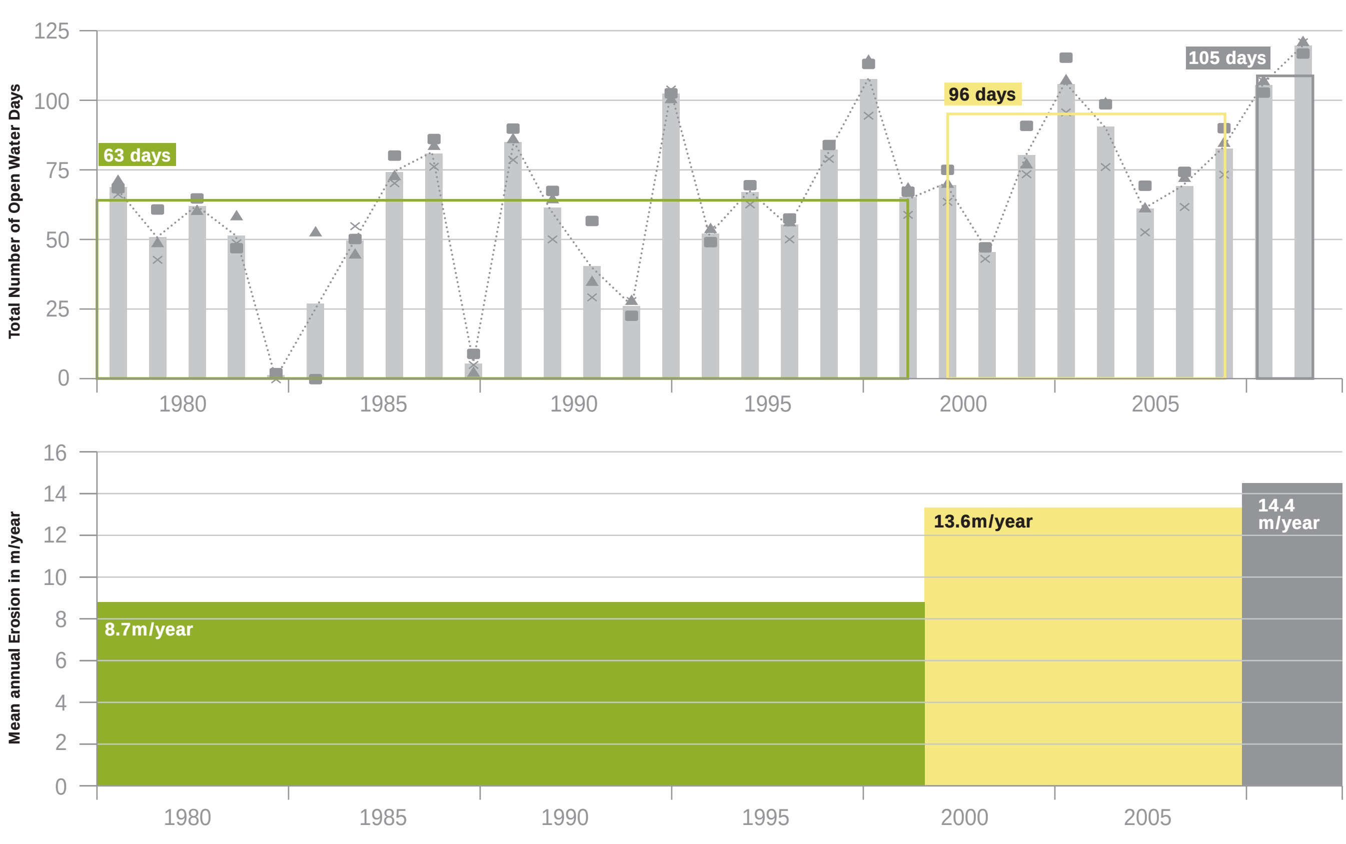
However, climate change will reduce the accessibility of many inland areas. All across the Arctic, changes in climate will create new vulnerabilities for infrastructure and present new design challenges.

Existing infrastructure – buildings, bridges, roads, railways and pipelines – built on permafrost will become more expensive to maintain as the permafrost layer across northern Alaska, Canada and Russia becomes unstable. A shortening season for winter roads (temporary roads carved out of snow or ice) is already creating access challenges for communities and mine sites across northern Canada [16]. Winter road seasons for travel across northern Alaskan tundra have declined from over 200 days in the 1970s to around 100 days in the early 2000s [17]. People and some goods can be flown in by air, albeit at considerable expense, but heavy machinery cannot.

Given conditions of rapid change in the physical environment, Arctic infrastructure will need to adapt to a much wider range of potential environmental conditions over the course of a multi-decade life [18]. This means that all across the north, future infrastructure will have to conform to different technical specifications, and may be more expensive to build.

A good example of the double-edged consequences of climate change on access is the (sub-Arctic) port of Churchill in northern Manitoba, one end of the long-promised 'Arctic Bridge' from northern Canada to

Figure 5. Increase in average number of ice-free days in the Beaufort Sea compared to rates of coastal erosion



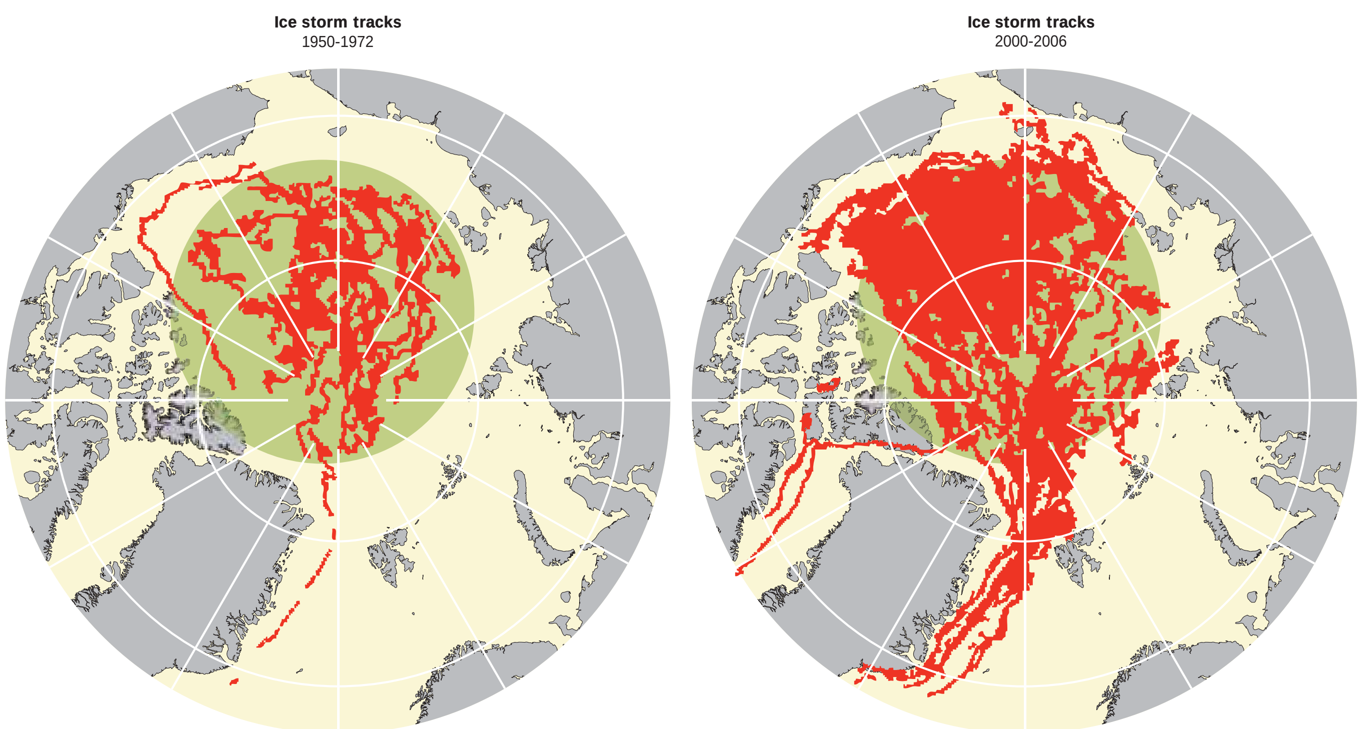
Source: National Snow and Ice Data Center - courtesy of Irina Overeem, University of Colorado[19]

Murmansk in northern Russia. While maritime access to Churchill has increased in recent years, creating the possibility of expanding sea-borne grain exports, the periodic thawing of permafrost on which the single-track railway line to Churchill is built can cause the track to buckle. This increases the risk of derailments, slows traffic and sometimes halts it altogether. Millions of dollars have been spent on repairing the line, but the costs of upgrading it permanently would be much greater.

There are challenges for coastal areas too. The number of open-water days in the Beaufort Sea north of Alaska and northern Canada (see Figure 5) correlates with increasing coastal erosion. The reduction in sea ice increases the distance over which waves gather strength – their 'fetch' – and increases the exposure of the coast. In low-lying areas of the Arctic – as elsewhere – any rise in sea level puts coastal infrastructure at risk.

Finally, on land, climate change may increase the frequency of extreme weather such as high precipitation or hotter than average Arctic summers, raising the risk of events such as flooding or forest fires [20]. At sea, many expect warming to make Arctic storms more severe, posing a different set of challenges for Arctic shipping and additional risks for coastal infrastructure, including the increased risk of storm surge (see Figure 6) [21].

Figure 6. Arctic storm tracks [xii]



Source: Nasa

[xii] S. Hakkinen, A. Proshutinsky, and I. Ashik, 'Sea ice drift in the Arctic since the 1950s', Geophys. Res. Lett., 35, 2008

box 2: Global Consequences of Arctic Environmental Change

As well as being affected by climate change, the Arctic itself also significantly affects global environmental change. The Arctic is crucial to global and regional weather patterns: anomalously large winter snowfall across Europe, North America and East Asia has been attributed to changes in Arctic sea ice [22]. The feedback loops that contribute to 'Arctic amplification' tend to accelerate global warming, while methane release from the melting of both onshore and seabed permafrost may increase atmospheric greenhouse gas concentrations. Many of the uncertainties in global climate models – crucial for determining appropriate policy responses – lie in Arctic processes. The importance of Arctic science to global climate science is shown in the greater priority given to polar science in recent years by both national and international research bodies.

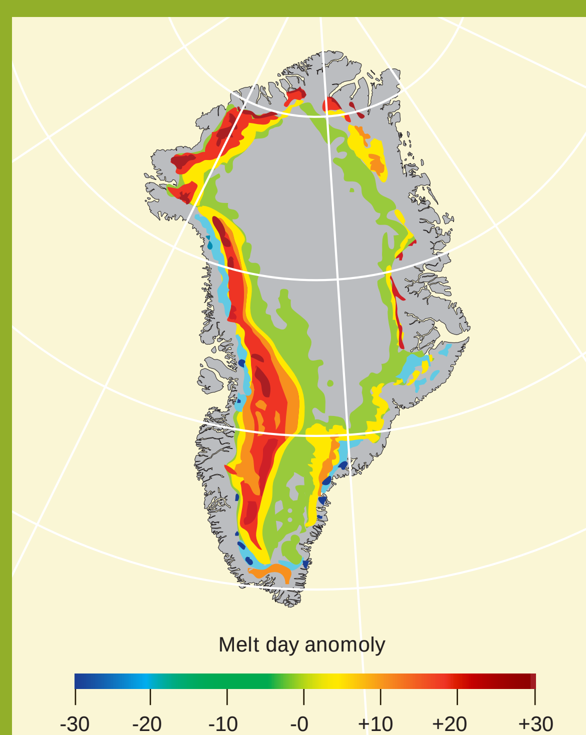
The main global consequence of Arctic environmental change is through a diminishing Greenland ice sheet. This is a long-term process. But, even over the course of the 21st century, it could have ramifications far beyond the Arctic.

The Greenland ice sheet contains approximately 2.85 million cubic kilometres of freshwater. Unlike annual sea ice melt, only a tiny proportion of this overall volume melts each year, and much of that is compensated for by fresh snowfall onto Greenland. However, also unlike with sea ice, any net reduction in the mass of ice on Greenland contributes directly to global sea levels [xiii]. Satellite measurements indicate that the mass of ice on Greenland is indeed declining [23].

For a range of reasons – including meltwater lubrication of the underside of glaciers, feedback mechanisms and the general trend of global warming – the rate of decline is accelerating [24]. Total ice sheet loss in 2011 was 70% greater than the average of 2003–2009 [25]. The number of melt days in 2011 was far above the average for 1979–2010, particularly in western and north-western Greenland (see Figure 7).

The rate of Greenland melt – along with that of Antarctic ice-shelves – is one of the key drivers of global sea-level rise. The influx of increased amounts of freshwater into the North Atlantic, meanwhile, could have broader consequences for heat carried by ocean currents which, in turn, could have consequences for weather patterns. And, although very far from immediate, there may be thresholds for the irreversibility of the decline of the Greenland ice sheet, meaning the original ice sheet volume could only be regained if the losses were no greater than 10–20% [27].

Figure 7. 2011 deviation from mean number of melt days on Greenland over the period 1979-2010



Source: City College of New York [26]

[xiii] The melting of floating sea ice has no direct impact on sea level when it melts because the displacement of sea is the same whether the water is in a liquid or frozen state.

2. Opportunity and Uncertainty: Charting the Arctic's Economic and Political Future

Though the prospects are significant, the trajectory and speed of Arctic economic development are uncertain.

The economic future of the Arctic is poised between opportunity and uncertainty.

Growing interest in four key sectors – mineral resources (oil, gas and mining), fisheries, logistics (including shipping) and Arctic tourism – could generate investment reaching $100bn or more in the Arctic region over the next decade, mostly in the minerals sector [28]. The epicentre of that investment is likely to be in the Barents Sea area, north of Norway and Russia, and in northern Alaska. Smaller investments, but with major local and international consequences, could occur in Greenland, Canada and elsewhere in the Arctic. A range of other economic activities – prospecting for biological material, harnessing Arctic hydro-power, and scientific research – may prove to be significant dimensions of economic development in some parts of the Arctic, but are not discussed in depth here.

Though the prospects are significant, the trajectory and speed of Arctic economic development are uncertain. Some aspects of Arctic development – particularly in the mineral resource sectors – depend heavily on global supply and demand dynamics. Investment projections often rely on a small number of mega-projects[xiv] (such as the Shtokman offshore gas development, or offshore oil developments in the South Kara Sea) which can be cancelled, delayed or scaled back depending on market conditions. For example, Arctic liquefied natural gas (LNG) projects will increasingly need to take into account North American shale gas production. Falling commodity prices would probably put many Arctic projects on hold.

In the meantime, there are huge infrastructure and knowledge gaps across the Arctic, constraining development and increasing the risks of frontier projects. There may be perceived trade-offs between different economic activities in the Arctic – such as between fishing and offshore oil and gas. The political and regulatory conditions in the Arctic, shaped by local, national and global policy priorities, are subject to change. Geological risks are inherent in mineral exploration activity in the Arctic as elsewhere (see Box 4). There are also additional risks, discussed in section 3 of this report; they range from a uniquely challenging range of operational risks, to the inevitable environmental risks caused by increased industrial activity and the constant possibility of environmental catastrophe with regional fall-out.

[xiv] Mega-projects are large scale investment projects typically costing more than $1billion.

2.1 Arctic mineral resources

Three key factors are sharpening interest in the Arctic's mineral resources:

- Feasibility: Technological improvements mean that many more resource projects are technically feasible and commercially viable while geological risks can be better managed.
- Commercial attractiveness: High commodity prices, coupled with uncertainty about access to resources elsewhere in the world, make a far wider range of potential Arctic projects attractive to investors.
- Access: Improving access to large parts of the Arctic reduces costs of operation and eases logistics.

These factors are strongly inter-related and tend to be mutually reinforcing. They apply across the full spectrum of mineral resource projects – from oil and gas to mining.

2.1.1 Arctic oil and gas

Resources and activity

The Arctic has been known to contain oil and gas for over two centuries. A petroleum reserve for the US Navy was established in northern Alaska as early as 1923 [xv].

However, commercial development is more recent. Discovery of the Prudhoe Bay field sparked renewed interest in the North Slope of Alaska in the late 1960s. The first oil shock of 1973, government support for domestic exploration, and concerns of international oil companies (IOCs) about being shut out of reserves in other parts of the world led to a decade-long boom in the US and Canadian Arctic in the 1970s [29]. The Trans-Alaska Pipeline opened in 1977 and North Slope production peaked a decade later. The exploration boom extended to Greenland in 1976–1977 with the drilling of five offshore wells, which all turned out to be dry.

Historically, activity in the European Arctic has been much lower. Exploration in the early 1980s in both the Norwegian and Russian Arctics resulted in a number of oil and gas finds, including Snohvit, Shtokman and Prirazlomnoye. In the 1990s, however, interest waned as new sources of oil and gas opened up and the oil price fell towards $10 a barrel. Large-scale Arctic exploration and development halted – except in Alaska, where the Trans-Alaska pipeline made it commercially viable [xvi].

[xv] The National Petroleum Reserve Alaska (NPRA) was initially the National Petroleum Reserve, established by order of President G. Harding in 1923.
[xvi] Seismic work continued in some areas – for example in offshore Greenland in the 1990s.

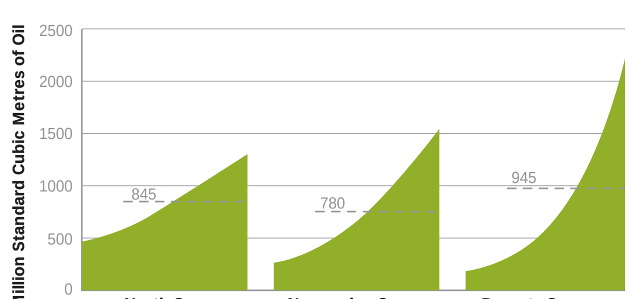
Several factors have substantially affected commercial and strategic calculations of Arctic development over the last decade. The improvement of exploration, drilling and offshore production technologies has increased the likelihood of finding oil and gas in any given location, and allowed larger areas to be developed with fewer oil and gas installations. Globally, access for IOCs to easy-to-produce reserves has been reduced (see commercial rationales and risks below). Finally, and crucially, the price of oil has increased.

In 2008, the United States Geological Survey estimated that the Arctic contained some 412.2 billion barrels of undiscovered oil and oil equivalent. Over two-thirds of this was estimated to be natural gas – approximately 46 trillion cubic metres, representing 30% of global undiscovered natural gas (approximately equivalent to Russia's entire current proven reserves of natural gas [30]). Some 90 billion barrels were estimated to be oil – 13% of the estimated global total of undiscovered oil, approximately three times the current total proven reserves of oil of the United States and more than three times the proven reserves of the world's largest non-state oil company, ExxonMobil.

The balance of oil and gas across the Arctic will vary. In general, the Russian Arctic is considered to be more gas-prone and the offshore Norwegian and American Arctics (including Greenland) more oil-prone [31]. Most Arctic hydrocarbon resources are likely to be on the near-shore continental shelves of the Arctic states.

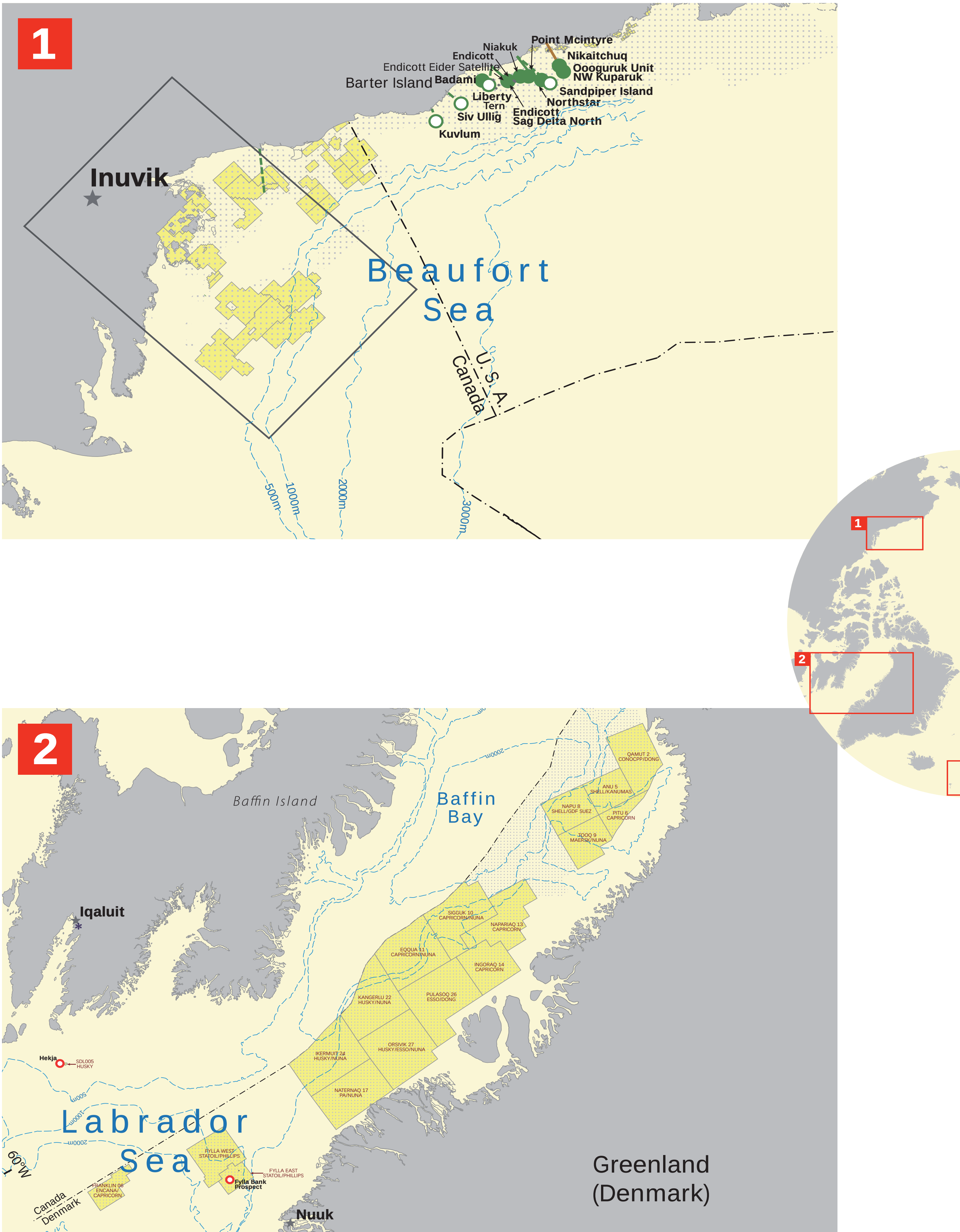
All these estimates are highly uncertain. Drilling data is scarce relative to highly developed areas such as the North Sea or the Gulf of Mexico. A comparison of the Norwegian Petroleum Directorate estimates for undiscovered oil in the North, Norwegian and Barents Seas shows the range of uncertainty around prospective oil resources in the Arctic is significantly greater than elsewhere (see Figure 8).

Figure 8. Range of estimates for undiscovered hydrocarbon resources in the North, Norwegian and Barents Seas

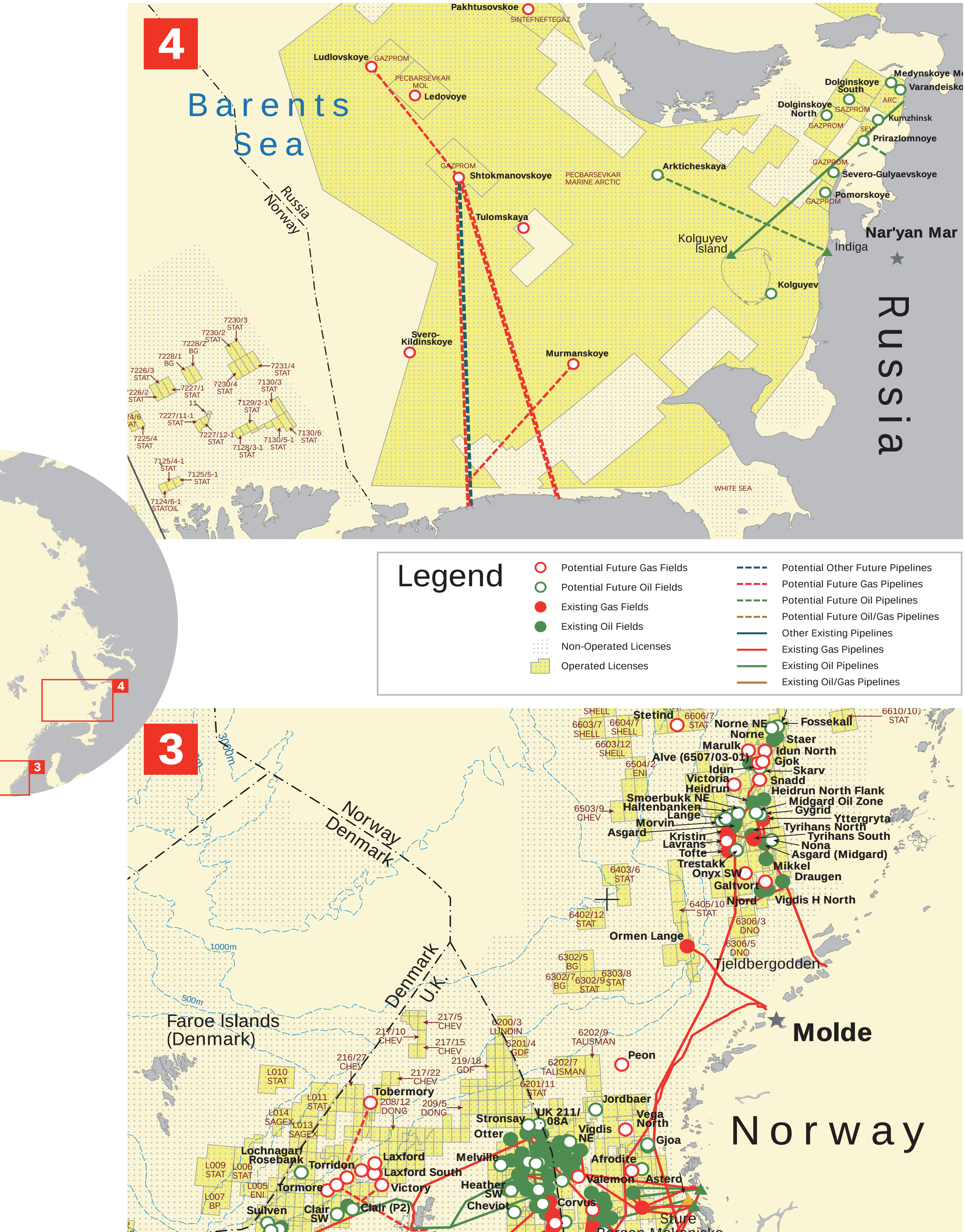


Source: The Resource Report 2011, Norwegian Petroleum Directorate October 2011

Figure 9. Current and potential future Arctic offshore hydrocarbons map



Source: Infield Systems Limited



The mean estimate for the Barents Sea in 2011 was 6 billion barrels of oil equivalent [32]. Over the course of a single year, with the announcement of the Skrugard oil find in January 2011 and the Havis oil find in January 2012, Statoil reported Barents oil finds amounting to 400–600 million barrels of recoverable oil equivalents.

Commercial rationales and risks

As elsewhere, geological uncertainties affect investment decisions in the Arctic. But, from a corporate perspective, geological uncertainty is partly offset by the prospect of discovering large fields – unlikely to be found in other parts of the world – that would justify large exploration expenses. The share valuation of IOCs is largely driven by the ratio of proven reserves – which can be 'booked' in a company's financial reporting [xvii] – to production. For companies excluded from equity stakes in many of the prime resource bases of the world, and within a diminishing range of investment options – including deepwater ones – the Arctic is increasingly attractive [xviii].

Further, companies exploring in the Arctic can acquire the technical expertise they will later need for production there. The Arctic has typically been a long-term investment: lead times from discovery to production remain long and there is limited Arctic-ready equipment to engage in exploration activity. It took Statoil 30 years of exploration and drilling in the Barents Sea before production. The company expects its Arctic exploration and production will speed up the rate of subsequent discoveries and potentially reduce production lead times [33].

The commerciality of any project or technique is based on expectations of future market prices for oil and gas. Expectations that the price of oil will remain in the $80–$120 range in real terms for the foreseeable future provide a strong incentive for exploration and increase confidence that prices will cushion the high costs of Arctic development (see Figure 10). However, global energy markets are in flux. Several studies suggest the potential of a peak in global oil demand, rather than supply, leading to subsequent terminal decline and lower prices [34]. A sustained oil price spike in the near term might accelerate that process [35].

The outlook for Arctic natural gas is different. In the future, European Arctic gas can be expected to reach consumers by pipeline, partly through existing Russian or Norwegian networks, and partly to compensate for declining gas production elsewhere in Europe and Russia.

Arctic oil installation.

[xvii] The listing of reserves in a company's financial reporting is subject to strict regulation.
[xviii] For example, national policies exclude foreign investment in upstream oil in Saudi Arabia and do not allow the booking of reserves in Iran.

The scope of this market is constrained by the level of European demand. The Russian government intends to use Arctic production to allow it to keep to its European commitments while attempting to capture a part of the growing Asian gas market.

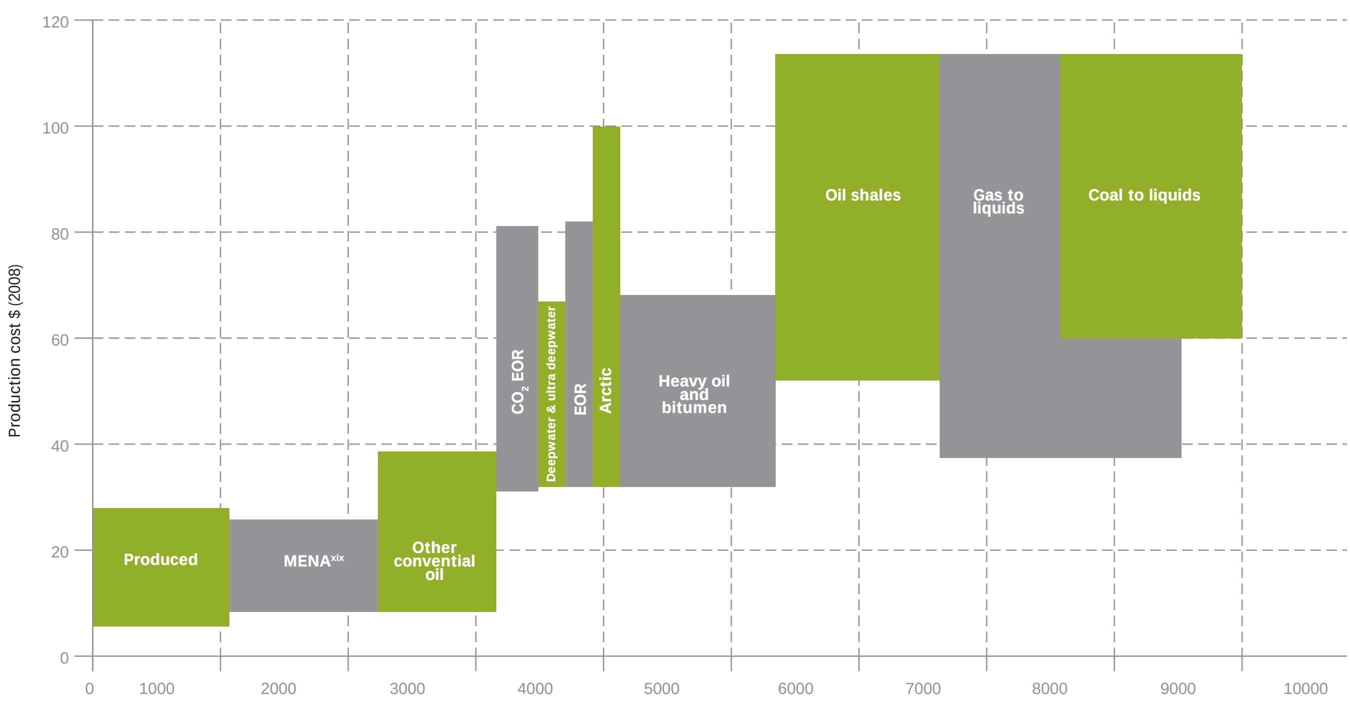
The broader global dynamics of natural gas are shifting, however. Natural gas is priced and sourced regionally, often resulting in significant price differences between markets – there are currently low natural gas prices in North America and high ones in East Asia. However, gas is increasingly marketed internationally in LNG form. Prices for gas could change dramatically if prices were decoupled from oil, or if there is a move towards a global price – as with oil – or if significant new gas supplies come on-stream. Shale gas production in the US, for example, has already led companies to drop out of the $30–$40bn project to pipe gas from Alaska's North Slope to US and Canadian markets [36]. In Asian markets Arctic LNG would have to compete with Australian and other Asian sources. In time, the continental United States may itself become a significant exporter if natural gas production is not diverted to its transport sector.

There is considerable variation amongst Arctic hydrocarbon projects. This has implications for their commercial viability, and for the business, operational and environmental risks associated with developing them. The estimated cost of producing a barrel of Arctic oil ranges from $35 to $100 (production costs in the Middle East are sometimes as little as $5 per barrel)[xx].

There are different potential offshore developments in both shallow water and deeper water. Some are in relatively inaccessible areas; others are in places with a history of oil and gas development. Some Arctic developments are commercially viable at a relatively low oil price, particularly onshore, and especially where there are sunk costs in terms of infrastructure. Other Arctic developments, such as offshore Greenland and the Barents Sea, with potentially higher production costs and a requirement for major infrastructure investment before development, need either a much higher price or a much larger find to be profitable.

The higher end of Arctic production costs is in line with current and projected oil prices for the next 10-15 years. However, given that lead times from prospecting to

Figure 10. Long-term oil supply cost curve



Source: International Energy Agency[37]

[xix] MENA refers to the Middle East and North Africa; EOR refers to Enhanced Oil Recovery. These are engineering techniques to increase the amount of crude oil that can be extracted from a field.

[xx] This depends on the productivity of the wells and the field, among other factors.

production are approximately ten years, the commercial value of undiscovered fields is far less certain.

For the most commercially marginal Arctic oil and gas developments, the tax regime applied may be a decisive factor in determining their viability. There is wide variation in the government take of profits from Arctic projects, depending on government-set regimes, price and production costs. A recent study suggested that, at a sale price of $80 and a production price of $25, the government take for Arctic oil projects would range from 100% in Russia (though this is changing) to 40–45% in Greenland and Canada [xxi]. As governments offer incentives for development, or as geological uncertainties are reduced, the government take is likely to shift. The Russian government's terms for Yamal's LNG development are described as being "among the lowest in the world" [xxii].

The UNFCC and its member states have publicly stated their commitment to meet a target of 2°C maximum temperature rise by 2020. A business-as-usual attitude to climate change will lead to a 4°C temperature rise, resulting in devastating impacts on people's lives and the global economy. To reach the 2°C target, the world's leading economies will need to commit to a significant increase in their use of renewable energy. Governments and companies should consider how the drive to develop Arctic oil and gas exploration will align with international action on climate change mitigation.

Current and future Arctic oil and gas investments

The scale of potential investment in both the onshore and offshore Arctic oil and gas industry is a small fraction of overall investment in the global oil and gas industry over the next 10–20 years: the International Energy Agency has suggested that overall investment in the oil and gas sector should total $20,000bn between 2011 and 2035 [38]. Nevertheless, sustaining current and projected rates of Arctic oil and gas could transform local economies and global energy dynamics. If implemented, the Russian government's ambitious vision for investment in its high north would establish the Arctic as a major gas-producing region.

Given regulatory, commercial and geological uncertainty, meaningful long-term investment projections in this sector are hard to come by and difficult to make [xxiii]. Each potential project faces a different set of technical, environmental and infrastructure issues: each country presents a different legal and political context that will influence investment. Box 3 looks at current investment projections for each territory.

Oil pumps in the Arctic.

[xxi] Pedro van Meurs, Barry Rogers, Jerry Kepes, World Rating of Oil and Gas Terms: Volume 3 – Rating of Arctic Oil and Gas Terms, Van Meurs Corporation Rodgers Oil and Gas Consulting & PFC Energy, 2011 (as reported in Petroleum Economist January 2012).
[xxii] 'Arctic investment competition heats up', Petroleum Economist, January 2012, available at www.petroleum-economist.com/Article/2959654/Arctic-investment-competition-heats-up.html

[xxiii] The offshore oil consultancy Infield has projected an average $7 billion annual investment in offshore Arctic exploration and development alone from 2011 to 2017. But this figure depends to a large extent on the 2016 go ahead for the Shtokman gas field development in the Barents Sea, a partnership between Gazprom, Statoil and Total.

Box 3: Arctic oil and gas investment commitments and projections

Russia

Shtokman is by far the largest single potential offshore Arctic project, 550 kilometres into the Barents Sea. Overall, investment could reach $50bn [39]. However, the Shtokman project has been repeatedly delayed owing to concerns about drifting icebergs, negotiations over the tax regime with the Russian government, and concerns about export markets [xxiv]. At the time of writing it is unclear whether the project will proceed, or to what schedule. Investments in the onshore Yamal peninsula – the lifeline for Gazprom's ability to maintain and increase Russia's overall gas production – could run to more than $100bn, in order to provide eventual production of 115–140 bcm, if not more [40]. In October 2011, Total paid $425m for a 20% stake in Novatek's Yamal LNG project – which is expected to require investment of $18–20bn to 2018 – while also taking a $4bn equity stake in Novatek [41].

In oil, TNK–BP plans to spend up to $10bn on developing onshore Arctic oilfields in the Yamal-Nenets Autonomous Area, with exports to Asia from 2015–2016[42]. Offshore, Gazprom's Prirazlomnoye platform is expected to be in place in 2012. In August 2011, the Russian state company Rosneft signed a deal with Exxon for three offshore blocks in the Kara Sea and one in the Black Sea, to which Exxon committed $3.2bn for the initial prospecting phase – most of this tabled for the Arctic areas. Russian Deputy Prime Minister Igor Sechin said this project would attract $200bn–$300bn in direct investment over the next 10 years, though this figure is highly speculative [43].

Norway

Given the arguably more stable regulatory and operating environment, investment in Norway's Arctic fields is more predictable. The Norwegian government expects the Snohvit gas field (producing gas for the Melkøya LNG plant) and the Goliat oil field (expected to produce from 2013) to attract a total of $9.2bn of investment ($2.17bn has already been spent to 2010) [44]. The Skrugard and Havis oil and gas fields, estimated to contain 400–600 million barrels of recoverable oil equivalents, are likely to produce sustained investment, with associated economic opportunities for oil service firms able to operate in the Barents Sea [45].

Canada

In Canada, there has been renewed interest in Arctic wells previously abandoned as unprofitable at the end of the 1980s. Several 9-year exploration leases were awarded between 2007 and 2010, subject to investment commitments of some $1.8bn. These projects have been on hold since May 2010 pending a review of offshore drilling (see section 3.3 and Appendix).

United States

In addition to on-going onshore oil production on the North Slope of Alaska, US companies are now also looking further offshore, beyond artificial islands which have been producing in the near offshore for some time. Shell, ConocoPhillips, Statoil, Repsol and Eni won exploration leases for the Beaufort and Chukchi Seas in 2008, paying out a total of $2.66bn[xxv]. Subsequent legal challenges and the 2010 post-Macondo moratorium on offshore drilling in Canada and the United States held exploration largely in check. In 2011, a report commissioned by Shell estimated "commercial production of Arctic Alaska offshore oil and gas resources would generate government revenue estimated at $97bn (in 2010 dollars) in the Beaufort Sea and $96bn in the Chukchi Sea over 50 years" [46]. In line with an increasingly supportive approach taken by the Obama administration to Arctic development, in December 2011 Shell received conditional federal approval for six exploratory wells.

Greenland

Between 2002 and 2010, hydrocarbon exploration costs in Greenland amounted to around $740m. A second licensing round for exploration acreage in the Greenland Sea will be held in 2012/2013. To date, Cairn Energy is the only company undertaking exploration; it has probably invested over $1bn in total to 2011, so far without major success. Greenland's national oil company, Nunaoil, has suggested the potential for $10bn in investment in the exploration-to-production phase in West Disko (2011–2030) and a further $10bn in Baffin Bay (2011 to beyond 2040) [47].

[xxiv] Other LNG supplies, from Australia and elsewhere, may mean that the window of opportunity for Arctic LNG exports is becoming more challenging.

[xxv] Shell was by far the most substantial bidder, paying $2.1 billion.

2.1.2 Mining

Mining has a longer history than hydrocarbon production across the Arctic. In the late 19th and early 20th centuries the quality of Arctic coal deposits (the principal fuel of shipping) led to investment and interest in the Svalbard archipelago, culminating in the Svalbard treaty in 1920 [xxvi]. For a long time, mining was Greenland's only economic export activity besides fishing.

More recently, and with less publicity than the growth of oil and gas interest in the Arctic, mining companies have increased their investments in the region. In some cases, the risks associated with air and water pollution of rivers and streams have made these investments as controversial as oil and gas projects. However, mining projects often offer better long-term potential for economic development than oil and gas, with a larger permanent and local workforce and a project lifetime of several decades, from prospecting and production to closure and rehabilitation.

Resources and activity

At the time of writing, there are currently 25 mines in operation in the Russian Arctic. These include the mines of Norilsk Nickel, a large Russian diversified mining company, the largest nickel producer in the world and a major producer of palladium and platinum [48]. In 2010, 36.8% of Alaska's foreign (non-US) export earnings came from exports of zinc, lead, gold and copper, generating $1.3bn [49]. The Red Dog mine is one of the largest lead-zinc mines in the world, employing 700 people, mostly year-round.

Greenland is already home to a number of mines, such as Swedish company LKAB's Seqi Olivine mine. The opening of coastal areas of Greenland to development, partly as a result of climate change, has increased the potential attraction of a range of other projects including gold, platinum and rare earth metals with high-technology applications at the Kvanefjeld deposit. Greenland's government does not currently allow development of the island's well-known uranium deposits, though its stance on exploration has recently been partially relaxed [50].

In Canada, mining accounts for half the income of the North-West Territories and geological mapping is strongly supported by the federal government [51]. Diamond mining north of Yellowknife has expanded rapidly. Between 2003 and 2008, total spending at a single mine, the Diavik diamond mine, amounted to $4bn, of which a substantial share was with local businesses [52]. The Mary River iron ore project on Baffin Island in Canada's Nunavut territory is due to enter development in 2013 and will require an estimated $4.1bn of direct investment up to 2040 [53].

Kovdor Mine, Russia.

[xxvi] Broadly the Svalbard treaty confirms Norwegian sovereignty over the Svalbard archipelago, but provides for access for treaty signatories (including Russia, the United Kingdom and others) on equal terms.

Icebergs dwarf a passing boat.

In northern Scandinavia, there are mining prospects across northern Sweden and Finland, and iron mines in Kirkenes (in northern Norway) and Kiruna. The latter is the world's largest underground iron ore mine and the world's largest Arctic mine – yet most of the ore is currently unmined [54].

Commercial rationales and risks

The reasons for mining company interest in the Arctic are broadly similar to those of oil and gas companies: the Arctic has been much less geologically explored than other parts of the world and consequently there is the potential for discovery of world-class deposits. However, the challenges and drawbacks are also similar: remoteness, lack of infrastructure and the potential of disruption to production schedules causing logistical bottlenecks and increasing costs. While maritime transport to mines may become easier, mining activity away from the coastline may become less accessible (see section 1.4).

Political risk around mining varies around the Arctic depending on the level and volatility of political support for mining and the legal regime under which it takes place. In some respects, however, political risk is lower than for oil and gas projects, given the lower profile of Arctic mining. Strict environmental regulations can pose major operational and technical challenges for mining, and tightening of regulation could affect the economics of some projects. Tax and royalty regimes, as with oil and gas projects, are critical to investment decisions. There are considerable risks of environmental damage from mining, though these tend to be more easily localised than the regional damage that can be caused by oil and gas accidents. However, from a corporate perspective mining risks are no different from environmental risks in other places.

2.2 Fisheries

Arctic fisheries are often overlooked in assessments of the resource wealth of the Arctic; they currently only represent around 5% of the overall global catch [55].

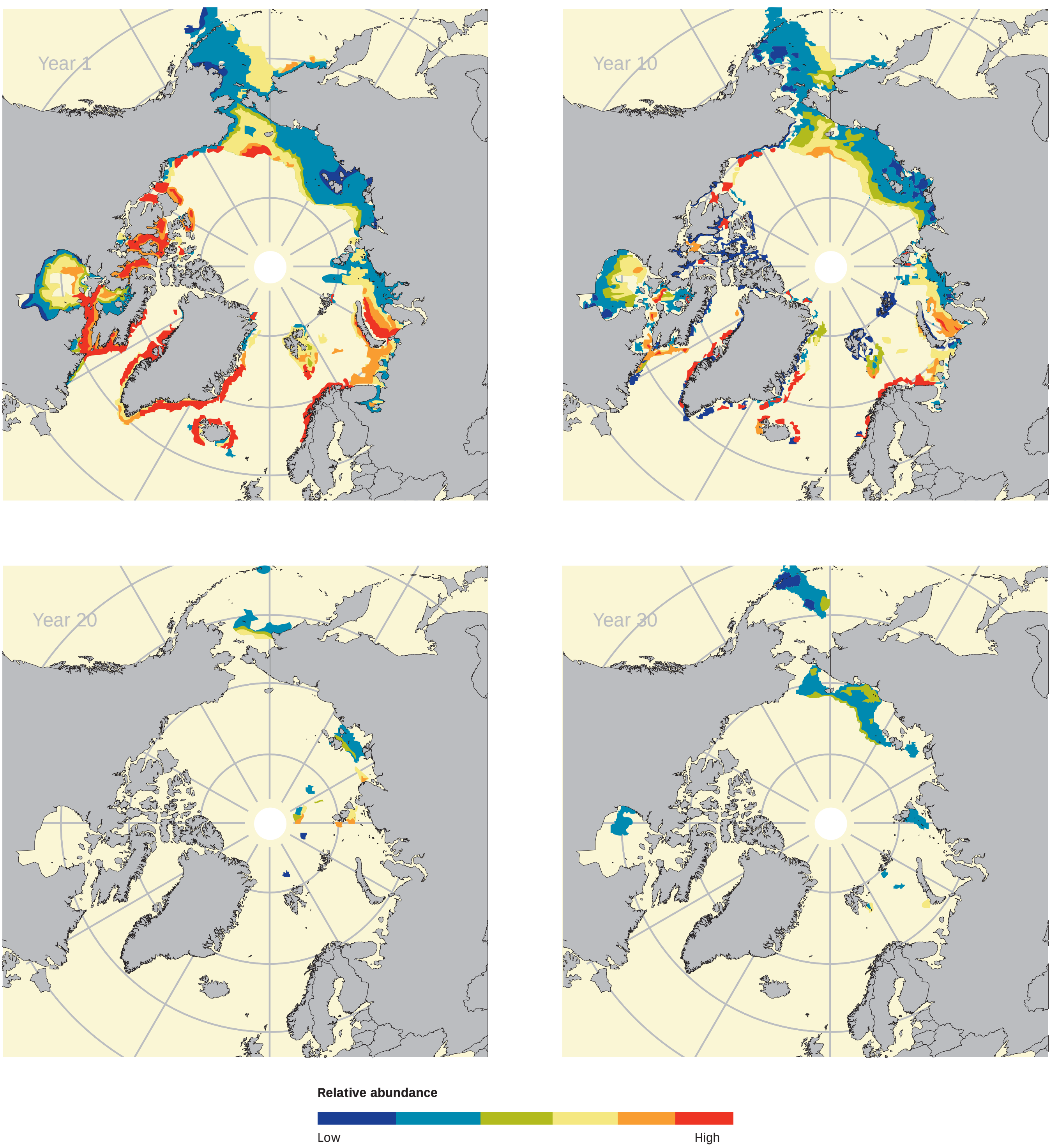
Yet fishing is historically a key industry – and employer – across the Arctic. Its economic relevance has been greatest in the smaller Arctic states. Fish represents 90% of the export earnings of Greenland, 33% of those of Iceland, approximately 6% of Norway's and less than 1% of the export earnings of the United States and Russia [56]. In 2011, exports of Norwegian cod amounted to $1.8bn, and exports of salmon from aquaculture some $4.8bn [57]. Meanwhile, individual Arctic communities are almost wholly reliant on fisheries and fish processing for their economic survival. Fishing communities are highly sensitive to marine pollution, they are often politically powerful in proportion to their size, and their interests may sometimes be at odds with other economic activities, including shipping and oil and gas development. For example, in Norway many fishermen oppose opening up the area around the Arctic Lofoten, Vesteraalen and Senja islands to oil exploration given the likely disruption to spawning habitats and risk of spills.

In some places, fishing activity has boomed in recent years. There were 30 fishing ship voyages in the Canadian Arctic in 2005, and 221 in 2010, by far the largest component of all ship voyages in the Canadian Arctic [58]. The Greenlandic shrimp catch has grown by half again over the last decade [59].

Historical data on Arctic fisheries are uneven. While the Barents Sea has been relatively well studied, not least because of long-standing fisheries co-operation between

Norway and Russia, data for other parts of the Arctic are hard to come by or, because of under-reporting, highly misleading [60]. Lack of data compounds the difficulty of predicting the likely future productivity of Arctic fisheries. Climate change may boost the productivity of aquaculture. The 20% increase in phytoplankton across the Arctic Ocean between 1998 and 2009 suggests that the bottom of the food chain in some places may flourish. But there are also concerns. In the longer term, the impacts of climate change on particular fish stocks could be highly negative as those stocks are crowded out by growing species (see Figure 11).

Figure 11. Modelled changes in distributions of Arctic cod over the next 30 years



Source: Conservation of Arctic Flora and Fauna (CAFF) - Arctic Biodiversity Trends 2010: Selected indicators of change [61]

Historical experience underlines the challenge of sustainable fishery management. Greenland's cod fishery produced between 300,000 and 400,000 tons annually in the 1950s and 1960s. Over the following two decades it collapsed, largely as a result of overfishing. By 2008 the cod fishery had recovered slightly, but was still less than 20,000 tons.

A US Senate Joint Resolution from 2008 called on the US government to pursue international agreement on a ban on commercial fishing in the Central Arctic Ocean, beyond the Exclusive Economic Zone (EEZ) of any Arctic coastal state (see section 2.5). In 2009 the United States government pre-emptively imposed a ban on the expansion of commercial shipping in US-controlled waters off Alaska.

2.3 Shipping and logistics

Maritime traffic in the Arctic is already considerable. The 2009 Arctic Marine Shipping Assessment reported 6,000 vessels active in the Arctic [62]. Year-round navigation has been maintained on the western part of the Russian Northern Sea Route (between Dudinka and Murmansk) since the late 1970s.

Seasonal conditions vary across the Arctic (see Figure 12). However, ice conditions are not necessarily worse in the Arctic than elsewhere. For example, in March 2011 ice conditions in the eastern Gulf of Finland outside the Arctic required a Russian nuclear icebreaker to be called in from the Arctic.

Figure 12. Current winter and summer conditions along the Northern Sea Route

	Kara Sea	Laptev Sea	East Siberian Sea
Winter Season	Oct-May	Oct-June	Oct-May/June
Temp typical	-26°C	-30°C	-21°C
Temp extreme	-48°C	-50°C	-48°C
Ice thickness	1.8-2.5m	1.6-2.5m	1.2-2m
Fog	100 days	75 days	80 days
Summer Season	June-Sept	July-Sept	Mid June-Sept
Temp typical	7°C	8°C	15°C
Temp extreme	20°C	26°C	30°C

Source: London Market Joint Hull Committee 2012/004

As shipping seasons extend, Arctic shipping costs are reduced and point-to-point demand increases, traffic is expected to increase in future years.

Already, each Arctic shipping season is marked by a new development. In 2011, the Sovcomflot-owned Vladimir Tikhonov became the first supertanker (Suezmax) to sail the Northern Sea Route, with a cargo of 120,000 tonnes of gas condensate. Later that summer, the largest ever bulk carrier crossed the Northern Sea Route when the Japanese-owned Sanko Odyssey, carrying 66,000 tonnes of iron ore concentrate, completed a voyage from the Russian Kola Peninsula to Jingtang in China. In the summer of 2012, the Korean-built and Norwegian-owned Ribera del Duero Knutsen is expected to become the first LNG carrier to transit the Northern Sea Route, from Norway to Japan.

Each of these voyages has had to take on expensive icebreaker support, with ships capable of breaking through several metres of ice, despite relatively little ice being encountered in 2010 and 2011. The largest and most powerful icebreakers can cost up to $1bn and take 8–10 years to build [63]. Hiring charges vary, but the average cost for escort through the Northern Sea route is around $200,000 [64].

However, carrier ships able to travel through ice of up to 1.5 metres without icebreaker support have been developed by the company Aker Arctic in Finland. As sea ice retreats and thins there is far greater prospect of Arctic shipping without icebreaker support for longer periods of the year, and ultimately all year round, in some parts of the Arctic.

This increase in traffic will put additional pressure on coastguards, search and rescue and hydrographic services. In 2012, a single shipping management system for the whole length of the Russian Northern Sea Route is due to be established. In Canadian Arctic waters, shipping is subject to the Arctic Waters Pollution Prevention Act (AWPPA). The International Maritime Organisation has issued guidelines for ships operating in Arctic areas, and these are currently being developed into what will become a compulsory Polar Code. Across the Arctic, considerable investment is being made in hydrographic services to improve seabed mapping for shipping – previously not a priority – and by national governments into improved surveillance and other capabilities.

The increase in traffic will also provide opportunities for specialised ship-builders and ship-designers, in the Arctic countries themselves and in new centres of ship construction in East Asia. Norilsk Nickel has invested heavily in ice-capable vessels to ship minerals from Arctic Russia to both Europe and China without icebreaker support [xxvii].

Which routes?

Most shipping journeys are currently re-supplying voyages to communities and installations in the Arctic and point-to-point rather than trans-Arctic. Although nuclear icebreakers – far more powerful than conventional diesel-electric icebreakers – make most places in the Arctic technically accessible all year round, most Arctic shipping remains seasonal, because ice reduces shipping speeds and incurs additional fuel costs, and because the cost of using icebreakers may make a voyage uneconomic.

If offshore Arctic oil and gas development increases, so will point-to-point maritime traffic, encouraging additional investment in marine infrastructure and ship design. The emergence of the Arctic as a large-scale, bulk-carrier transport corridor is a longer-term prospect, though the first steps towards establishing it have already been taken. The basic commercial logic behind trans-Arctic shipping is the shorter geographic distances involved, and the expected resulting decrease in days at sea and fuel costs (see Figure 13).

Figure 13. Distances and potential days saved for Asian transport from Kirkenes (Norway) and Murmansk (Russia)

Destination	Via Suez Canal			Through Northern Sea Route			Days Saved
	Distance, Nm	Speed Knots	Days	Distance, Nm	Speed Knots	Days	
Shanghai, China	12050	14.0	37	6500	12.9 [xxviii]	21	-16
Busan, Korea	12400	14.0	38	6050	12.9	19.5	-18.5
Yokohama, Japan	12730	14.0	39	5750	12.9	18.5	-20.5

Source: Tschudi Shipping Company A/S

Distance is important, but it is not the only consideration in determining how fast the Northern Sea Route, or other trans-Arctic shipping routes, will develop. Navigability of particular routes in terms of sea-depth, knowledge of the seabed, availability of suitable ships and the risks associated with

Nuclear ice breaker heading to the North Pole.

[xxvii] In September 2010 the ice-class diesel-electric Norilsk Nickel-owned Monchegorsk sailed from the Siberian port of Dudinka, near Norilsk on the Yenisey river, to Shanghai, without ice-breaker support. The ship returned to Dudinka in November, taking just over 7 days to travel from Cape Dezhnev on the Bering Strait to Dudinka (2,240 nautical miles).

[xxviii] Based on an actual voyage performed by M/V Nordic Barents from Kirkenes to Lianyungang (China), September 2010.

Figure 14. Maritime accessibility in 2000-2014 and 2045-2059 (Type A vessels, July-September)[66]

Route	Length (km)	% accessible, 2000-2014	% accessible, 2045-2059	Accessibility change (%) relative to baseline	Transit time (days), 2045-2059
Northwest Passage	9,324	63%	82%	+30%	-
Northern Sea Route	5,169	86%	100%	+16%	11
'North Pole' Route	6,960	64%	100%	+ 56%	16
'Arctic Bridge'	7,135	100%	100%	+ 0%	15

Source: Reprinted by permission from Macmillan Publishers Ltd (Nature Climate Change) 'Divergent long-term trajectories of human access to the Arctic', Copyright 2011 [68]

Arctic shipping are all factors (see section 3). The existence and location of trans-shipment ports – to allow transfer between Arctic and non-Arctic vessels – may shape Arctic maritime logistics in the future.

The cost competitiveness of Arctic routes relative to more southern routes may be constrained by:

- The time taken to issue permits and the cost of these permits relative to other passages.
- The relatively slow speed of ice-breaking transport vessels (where still required).
- The challenge of full utilisation of tonnage capacity in both directions [xxix].
- The cost of insurance.
- The need to prepare vessels for Arctic conditions through winterisation processes (such as installing ice navigation radar systems, heating arrangements for pipes, on-board ice removal equipment and ensuring the ship's bridge is fully enclosed [65]).
- The infrastructure, surveillance and management of Arctic sea-lanes.

A comparison of two often-cited Arctic shipping routes – the Northwest Passage through Canada's Arctic and the Northern Sea Route across the northern coast of Russia – suggests that the Northern Sea Route is more likely to be subject to large-scale development over the next 10–20 years because of political support, projected ice conditions (see Figure 13) and the development of onshore and offshore mineral resources in the Russian Arctic [66].

The Northern Sea Route may ultimately become a major global energy corridor between Russia and East Asia. While trans-Arctic shipping volumes along the Northern Sea Route are insignificant compared with overall global shipping volumes, total cargo has increased by a factor of ten in recent years (though from a historically low level following the collapse of the Soviet Union) [67].

Looking to the future, by the middle of the coming century, Arctic conditions may have changed so much that a shipping route across the North Pole, bypassing the Northern Sea Route and the Northwest Passage, becomes commercially viable (see Figure 14).

2.4 Arctic Tourism

Tourism has a long history in relatively well-developed parts of the Arctic, such as coastal Norway. Improved accessibility has increasingly allowed tourism to develop in less populated and economically developed areas, creating a substantial seasonal economy. The number of nights spent at hotels in Greenland increased from 179,349 in 2002 to 236,913 in 2008 [69]. In Longyearbyen, on Svalbard, these numbers rose from around 30,000 in 1995 to over 89,000 in 2008 (before declining to 77,000 in 2010) [xxx]. Arctic tourism has not only become more common, it has also become far more global, with greatly increased numbers of tourists from outside the home country.

The cruise sector, less constrained by limits on onshore tourist accommodation and more difficult to regulate because it operates in offshore areas, has also expanded substantially. In 2003, an Association of Arctic Expedition Cruise Operators (AECO) was set up to support and establish best practice for cruises, particularly in the Norwegian Arctic. Of fifteen AECO vessels off the coast of eastern Svalbard in 2011, five were Russian-registered, three Dutch, two from Nassau Bahamas, two registered in the Bahamas, and one each French, Panamanian and Swedish [70].

Many of the challenges associated with cruise ship tourism in the Arctic are similar to those affecting commercial shipping: relatively poor knowledge of seabed features, lack of infrastructure in terms of port facilities, and the need for

[xxix] Ships used in the Arctic may be useful for one-way voyages where a cargo is to be carrried from A to B, but in order for such voyages to be commercially viable, the ship must be able to return to the point of departure, preferably with a cargo to defray the costs of the return journey. Economic viability is therefore enhanced by two-way traffic.

[xxx] The final figures for 2011 are expected to show an increase in the previous year.

A cruise liner nears a glacier.

winterisation of vessels and the removal of deck-icing. In 2010 the MV Clipper Adventurer cruise ship ran aground in the Canadian Arctic on a rock initially claimed to be "uncharted". The Canadian Coast Guard took two days to reach the vessel. There has been subsequent legal disagreement over potential compensation. While the Arctic Council reached a pan-Arctic Search and Rescue (SAR) Agreement in May 2011, providing a firm basis for co-operation between Arctic states, search and rescue infrastructure and capability remain constrained (see section 3.1).

2.5 Arctic Politics

The Arctic is, in general terms, a stable region with considerable mutual trust between states. The Arctic Council – comprising the eight Arctic states, permanent participants and observers – represents the key role of dialogue in Arctic governance politics [xxxi]. Nevertheless, there is naturally a range of potential stress points within and between the eight Arctic states, and between these states and non-Arctic states. A number of potential shifts are in sight within Arctic geopolitics – from the possible independence of Greenland, to the increasing involvement of non-Arctic states such as China in Arctic politics, and the risks of misunderstanding arising from a build-up of Arctic states' military hardware. However, while any of these factors could affect Arctic politics, and all need to be managed, none of them are likely to fundamentally change the co-operative nature of Arctic politics and governance. The key question, therefore, is the extent of co-operation rather than the possibility of outright conflict.

[xxxi] Other Arctic forums include the Barents Euro-Arctic Council and the Nordic Council.

2.5.1 Who owns what? Who controls what?

Ownership of the Arctic is principally determined by ownership of land in the Arctic, by scientific data, by the international law of the sea and by the domestic law of Arctic states [71].

Most parts of the land of the Arctic are beyond dispute – Hans Island is the only area of minor dispute between Canada and Denmark.

All Arctic states, except the United States, have ratified the UN Convention on the Law of the Sea (UNCLOS) which establishes the global framework of rules for rights and responsibilities on the world's oceans, including determining how far states can claim sovereign rights over resource-rich areas [xxxii]. In May 2008 five coastal states – Canada, Denmark (Greenland), Norway, Russia and the United States – re-committed themselves to the framework of the law of the sea and to the orderly settlement of overlapping claims [xxxiii].

Under the law of the sea, all states exercise an exclusive economic zone (EEZ) 200 nautical miles (370 kilometres) from their coastline, giving them economic rights over the water and seabed resources up to that point. Most potential offshore oil and gas developments are well within this limit. Although land borders are not disputed, adjacent states may disagree over their maritime borders. Canada and the US disagree over their maritime border in a potentially hydrocarbon-rich area of the Beaufort Sea. Norway and Russia agreed a new maritime border in the eastern Barents Sea in 2010 after 40 years of dispute, opening the way to oil and gas exploration.

Beyond the EEZ, in the Arctic as elsewhere, states may have ownership over the economic resources of the seabed – the extended continental shelf – up to 350 nautical miles (650 kilometres). Beyond these areas of the seabed, other provisions of the law of the sea determine the conditions under which resources could be developed, were they to be discovered [72].

Establishing ownership over the extended continental shelf depends on a range of geological and geomorphological factors, often requiring expensive and large-scale data collection. The Commission on the Limits of the Continental Shelf (CLCS) provides recommendations to states which provide submissions to

[xxxii] The United States views UNCLOS as representing international customary law.
[xxxiii] Iceland and the non-coastal states (Sweden and Finland) were not present, leading to suggestions that the Arctic Council was being circumvented in favour of a new grouping: the A-5

the CLCS. Some states have co-operated bilaterally in data collection for UNCLOS submissions, both to share the cost of research and to increase mutual trust. It is possible for states to make joint submissions.

States have ten years to make submissions to the CLCS from ratification of UNCLOS. Russia provided a submission in 2001 and was told to supply more data to establish its case. This is expected to happen in 2012. Norway submitted data in 2006 and received recommendations in 2009. Canada and Denmark have until 2013 and 2014 respectively to make submissions. The United States is not able to make a submission, but maintains that UNCLOS recognises rights rather than establishes them, and is active in collecting data.

There is potential for other states to challenge Arctic states' submissions and for the areas they cover to overlap at their outer edges. If this happens, states will have to negotiate between themselves, with the CLCS potentially playing an advisory – but not binding – role. While it is conceivable that a state might fail to agree with a CLCS recommendation, the political costs of doing so would be high in terms of breaking with the prevailing legal arrangements of the Arctic. Either way, the CLCS has a considerable backlog of submissions, meaning that full legal clarity in the near term may require co-operative submissions.

There are some other areas of disagreement. Norway asserts that the Svalbard Treaty does not apply to Svalbard's potentially mineral-rich continental shelf. Others disagree. Norway has invited them to seek a ruling of the International Court of Justice. Russia and Norway have long disputed fishing rights around Svalbard. An official Russian government strategy on the Russian presence on Svalbard up to 2020 is expected shortly.

Canada's position on the legal status of the North West Passage – that it comprises internal Canadian waters – is disputed by the United States and others. The United Kingdom views the Northwest Passage and the Russian Northern Sea Route as international waters. The legal rights of coastal states to regulate shipping in ice-covered waters under UNCLOS may be challenged because of climate change, as specific UNCLOS provisions applying to ice-covered waters may be considered no longer applicable.

But sovereignty and ownership are only one aspect of legal issues in the Arctic. Equally salient may be the establishment of international regulations and guidelines, such as through the International Maritime Organisation.

In most parts of the Arctic – and particularly onshore – it is domestic regulation and domestic legal challenges rather than uncertainties over the international legal position that are likely to affect economic development and investment.

2.5.2 The geopolitics of Arctic energy

Arctic oil and gas resources are highly politicised. Within most Arctic countries, oil and gas development is politically controversial on environmental grounds and can have a significant influence on the political dynamics between central and local governments. Over time, the integration of the Arctic economy into the global economy – principally through energy and transport – will further increase its geopolitical relevance.

In the US, the opening of further areas of the US Arctic to exploration and, ultimately, development has strong support within Alaska, but limited support elsewhere [xxxiv]. In Canada, Arctic energy and mining projects play into complex federal politics and the domestic politics of indigenous peoples across the north. In Greenland, exploration for offshore hydrocarbons is widely accepted as a pathway to greater economic prosperity and a guarantee of self-government. In Russia, maintaining oil production and increasing production of natural gas is a strategic imperative. In Norway, government and public support for development is contingent on strong environmental regulation.

There is a key geopolitical dimension to Arctic oil and gas developments, involving states' power, stability and influence. This is particularly true of Russia, where hydrocarbons represent 40% of export earnings and the state budget depends on taxes and royalties from hydrocarbon production. Russia's gas exports are a major feature of its geopolitical role in Europe, while expanding oil and gas exports to China has become an important policy objective for the Russian government. Nonetheless, development of the Russian oil and gas sector in the Arctic – particularly offshore – depends to some extent on the participation of Western oil and gas firms with the technology and management skills to develop them.

The development of Norwegian gas production, and the potential for export via existing pipeline networks to which the United Kingdom is connected, may reduce European dependence on other sources of gas. In November 2011

[xxxiv] The development of domestic energy supply is a major political issue in the United States, and was a motivating force behind the permitting of the Trans-Alaska Pipeline in the 1970s. Support for drilling in offshore Alaska – and in sensitive onshore areas such as the Arctic National Wildlife Reserve (ANWR) – is greater in Alaska for a number of reasons; jobs associated with the oil and gas industry, state revenues, and because all residents receive an annual dividend payment from the Alaska Permanent Fund, in to which a share of oil revenues have historically been diverted.

British company Centrica signed a 10-year, £13bn ($20bn) supply deal for natural gas from Norway, following a wider UK–Norway Memorandum of Understanding on energy[73].

Increased oil and gas production in Arctic North America is often presented as a way of improving US 'energy security', though export prospects to Asia may ultimately trump home markets. Investments across the Arctic are increasingly international – with interest from Indian, Chinese and South Korean companies.

2.5.3 Arctic governance

Arctic governance is multi-layered. Responsibility for governing the Arctic lies principally with the eight sovereign Arctic states operating through their domestic administrative and legal systems and, where they chose to, through bilateral arrangements and international treaties, such as the 2011 Arctic Search and Rescue Agreement. All the Arctic states, however, have other affiliations and roles within the international system – in NATO, the European Union or the UN Security Council – which affect their perspectives on Arctic governance and their ability to shape it.

International agreements – for example on biodiversity, or on certain pollutants – also apply to the Arctic. There are a number of other governance bodies involved in creating rules and regulations for Arctic activity, the most prominent of which is the International Maritime Organisation.

However, the essential organisation in Arctic governance frameworks is the Arctic Council, a forum for coordination and co-operation between the Arctic states on a range of issues, excluding security, but including environmental monitoring and the creation of common standards for shipping and oil and gas development. The eight Arctic states are all equal members of the Arctic Council. The Council also includes a number of non-voting permanent participants. Most of these are indigenous groups and some are highly influential in the domestic politics of Arctic states. There are also a number of permanent observers, including France, Germany and the United Kingdom.

In 2008, it appeared that a separate caucus group was emerging within the Arctic Council, comprising the five Arctic coastal states – Canada, Denmark (Greenland), Norway, Russia and the United States or collectively the A-5 – but excluding Iceland and the non-coastal states[xxxv].

Perhaps more significantly in the long term, the Arctic Council is currently discussing the application of criteria for the status of permanent observers. These criteria were established in 2011 following disagreements between Arctic states as to how to approach applications from non-Arctic states – including the European Union and China – for permanent observer status. A final decision on these states should be taken in spring 2013.

Figure 15. The Arctic politics matrix

	UNCLOS signatory? (Year ratified)	Arctic continental shelf claim? (Year submitted to CLCS)	Arctic Council?	A-5	Permanent Member of the United Nations Security Council	EU	NATO	Dedicated polar research?
Canada	2003	(Expected 2012/2013)	✓	✓			✓	✓
Denmark (Greenland)	2004	(Expected 2013/2014)	✓	✓		Greenland is not part of the EU	✓	✓
Finland	1996		✓			✓		✓
Iceland	1985	2009 (under consideration)	✓			EU candidate	✓	✓
Norway	1994	2006 (adopted 2009)	✓	✓		EEA state	✓	✓
Russia	1997	2001 (revised submission expected 2012)	✓	✓	✓			✓
Sweden	2003		✓			✓		✓
United States	Not ratified	Data collection; but no timeline for submission	✓	✓	✓		✓	✓
China	1995							✓
France	1996		Permanent observer		✓	✓	✓	✓
Germany	1994		Permanent observer			✓	✓	✓
India	1995							✓
Japan	1996							✓
South Korea	1996							✓
United Kingdom	1997		Permanent observer		✓	✓	✓	✓

Source: Chatham House

[xxxv] This exclusion provoked some concern amongst other Arctic Council member states. In 2010, the United States, itself a member of the A-5, publicly criticised the A-5 format at a second meeting held in Canada. Nonetheless, the possibility of future A-5 meetings has been left open by several Arctic states.

3. Assessing and managing Arctic risks

Though risks can, and should, be mitigated through prudent corporate risk management, public interest and prevailing regulatory frameworks, they cannot be eliminated entirely.

The Arctic is a complex risk environment. Many of the operational risks to Arctic economic development – particularly oil and gas developments and shipping – amplify one another: remoteness, cold and, in winter, darkness.

At the same time, the resilience of the Arctic's ecosystems in terms of withstanding risk events is weak, and political sensitivity to a disaster is high. Worst-case scenarios may be worse in the Arctic because the ability to manage evolving situations is limited by environmental conditions and the lack of appropriate infrastructure.

Though risks can, and should, be mitigated through prudent corporate risk management, public interest and prevailing regulatory frameworks, they cannot be eliminated entirely. The potential commercial opportunities – to discover and extract substantial quantities of oil and gas or to reduce shipping costs – may encourage some companies to take on greater business, operational and political risks. However, it is for governments to decide what is an acceptable level of environmental risk, and to establish their preferred policy outcomes. Perceived risks and political tolerance to risk may change, as happened in the United States after the Macondo blowout, and these may be at odds with companies' assessment of risks.

This report has already identified a number of key uncertainties around the future economic and political trajectory of the Arctic, including the scale of hydrocarbon resources, the future location and predictability of sea ice, and the wider consequences of climate change. These uncertainties are the greatest risks to potential investors in Arctic economic development. The extended lead-times in Arctic projects, which often relate to a matrix of other risks and infrastructure gaps, can change the overall economic situation by the time any investment becomes productive. While this is a familiar business risk that may be balanced by economic opportunity, it underlines the need for improved knowledge, risk assessment and risk management in the Arctic context.

3.1 Operational risk factors

Even under conditions of climate change, the Arctic remains a frontier operating environment. Many operational risks will continue to be an issue for parts of the Arctic year even under a warming climate. Other factors may be worsened or complicated by climate change.

Geographic remoteness

Many parts of the Arctic are geographically isolated, bringing operational challenges, entailing substantial costs and amplifying the potential consequences of risk events.

The infrastructure and capability to manage accidents may be distant or unavailable. In November 2010, the Pew Environmental Trust released a report questioning the capability of current infrastructure and technology to deal with a spill in some Arctic areas, arguing that until there is better research on marine ecosystems and the effects of an oil spill on them, these areas should remain off-limits to development [74].

Positively, the pan-Arctic Search and Rescue (SAR) Agreement signed in May 2011 committed Arctic states to provide resources to SAR within defined geographic zones – in areas beyond their own jurisdiction – where they can. But the ability to adequately cover these areas, particularly if there is increased activity, is still uncertain. Information about SAR services and their availability differs from country to country.

A study of the operating conditions of Norway's SAR helicopter missions in the Arctic showed that the nearest base for the Norwegian Barents is in Banak Military Airfield, Lakselv at 70°N, in Finnmark [xxxvi]. Since the sinking of the Kolskaya oil rig in December 2011, Russia's preparedness for emergencies has been questioned. Particular concern exists over the offshore Prirazlomnoye platform, some 1,000 kilometres from the nearest sizeable port at Murmansk, which is designed to store up to 840,000 barrels of oil [xxxvii]. Environmental groups and others in the United States and Canada have long expressed concerns about search and rescue and clean-up capacity in Arctic areas [75].

In some cases this will involve substantial additional costs if private companies are to operate safely and responsibly in the Arctic: Gazprom has stated its willingness to pay almost $550m for a sea-based helicopter platform at the Barents Sea [76].

Greenland wilderness from the air.

[xxxvi] This base has one helicopter with medical staff on board, which has been able to deal with most serious injuries. Besides this, there are some Norwegian Coast Guard ships with SAR-equipped helicopters on board. For more information about the statistics and effectiveness of Norwegian SAR missions in the Artic see Haagensen, R.; Sjøborg, K.A.; Rossing, A.; Ingilæ, H.; Markengbakken, L. and Steen, P (2004) 'Long Range Rescue Helicopter Missions in the Arctic', Prehospital and Disaster Medicine, Vol. 19, No. 2.
[xxxvii] Nataliya Vasilyeva, 'Kolskaya Oil Rig Sinking Sparks Doubt Over Arctic Plan', Huffington Post, 23 December 2011.

Cellular phone station.

Electronic communications challenges

Magnetic and solar phenomena, interference and geostationary satellite geometry all mean that high-frequency radio and GPS are degraded above 70°-72° North, a major issue for communications, navigation, and search and rescue. Limitations and expense of high rate satellite communications may be partially resolved over the next few years with the launch of a number of Arctic-specific satellite communications systems by the European and Canadian space agencies [xxxviii]. The Iridium constellation of communications satellites provides communication services that operate in the Arctic environment, albeit with limited bandwidth.

Climate change-related factors

Access to some parts of the Arctic is expected to improve, particularly in coastal areas, and principally as a result of changing maritime conditions. In other parts of the Arctic, however, accessibility may decline, as melting permafrost (soil at or below the freezing point of water) damages fixed infrastructure and as shorter winter road seasons reduce accessibility by land (see section 1.4). Melting permafrost may present additional challenges for onshore oil and gas drilling by raising the risk of drill-rig instability (see box 4).

Weather

Weather can change quickly in the Arctic, weather stations are relatively sparse, and weather forecasts are generally more uncertain owing to satellite constraints. In some places, the range of temperatures from winter to summer, and even the range of temperatures within a single day, means that designs have to be adapted and special materials used for Arctic construction, such as steel that is less brittle. The length of winter Arctic nights remains a challenge for operations. Low temperatures, in the Arctic as elsewhere, can cause machinery to seize up and, in high winds, make wind-chill extremely dangerous for workers. Companies must also adhere to more stringent health and safety procedures such as limitations on outside work in low temperatures. All of these have implications for operating procedures, and costs [77].

The Trans-Alaska Pipeline system, in almost continuous operation since 1977, was temporarily shut down in January 2012 as a result of weather conditions reported as “not uncommon” [78]. The closure caused an estimated daily loss of $18.1m to the Alaskan government in taxes and royalties from the sale of oil [79].

Icing and icebergs

Icing is a serious hazard for Arctic shipping, causing machinery to seize up and making vessels more top-heavy. It is also a major problem for coastal infrastructure, particularly in places exposed to sea-spray and storms. Statoil’s Melkøya LNG plant, just outside Hammerfest in Norway, the only such plant above the Arctic Circle, has reported a number of technical difficulties, some of which relate to location, temperature and icing [80]. At the time, Norwegian media speculated that the problem cost Statoil $34–$51m a week in lost revenue [81].

Conditions vary around the Arctic and most of these challenges are neither new nor particular to the areas above 60º North that are the primary focus of this report. As already noted, sea ice conditions around Sakhalin and the Sea of Okhotsk – in Russia’s Far East and far south of the Arctic Circle – are far worse than those off the north coast of Norway. Iceberg management systems are in use off the coast of sub-Arctic Newfoundland, Canada, identifying icebergs far from vulnerable installations, deflecting icebergs with tugs if possible and allowing sufficient time for installations to move off if deflection is not possible [82].

Many of these challenges can be managed – though at additional cost – through the application of existing technologies, through specific design and build specifications, or with adapted processes and additional infrastructure. However, the combination of factors means that the Arctic will remain a frontier operating environment, with or without climate change. The mitigation of these operational risks implies not only corporate investment but also government participation and support, in order to maintain and ensure adequate levels of surveillance and management.

[xxviii] Dufour, Bastien (2009) ‘Polar Communications & Weather (PWC) Mission Overview’, Canadian Space Agency, presentation available at www.envirosecurity.org/arctic/Presentations/EAC_Dufour.pdf

3.2 Risks to the environment

The Arctic environment is, in general, highly sensitive to damage. Relatively simple ecosystem structures and short growing seasons limit the resilience of the natural environment, and make environmental recovery harder to achieve. Damage to the Arctic environment, if it occurs, is likely to have long-term impacts. However, the Arctic is not one ecosystem, but comprises a variety of ecosystems and environmental conditions. The vulnerability of each ecosystem depends on a range of factors, including its complexity and structure. In all cases, baseline knowledge about the natural environment and consistent environmental monitoring is a prerequisite for measuring and understanding environmental impacts.

Pollution from outside the Arctic

The Arctic has long been exposed to the effects of pollution from outside the region. Black carbon – essentially small dark particles of soot from the burning of fossil fuels – has been associated with processes of rapid Arctic warming through its additional absorption of solar radiation [83]. Industrial pollutants are transferred to the Arctic by both air and sea. Approximately 100 tonnes of airborne mercury derived from industrial pollution are deposited in the Arctic Ocean annually. A process of bio-accumulation in Arctic fauna – essentially the aggregation of pollutants at higher levels of the food chain – has led to concentrations of some heavy metals and POPs that are far higher than outside the Arctic [84]. Ultimately this has an impact on human health, often the last link in the Arctic food chain [xxxix].

While the path pollution takes and the processes that cause it to accumulate in fauna cannot easily be stopped, cutting global emissions would have a direct impact on concentrations of pollutants in the Arctic. However, under a ‘status quo’ scenario mercury emissions worldwide would increase by 25% in 2020 over 2005 levels. As emission sources for some pollutants move closer to the Arctic, they will inevitably have an impact on the local and wider natural environment.

Climate change, by melting ice in which pollutants may currently be locked, may directly worsen concentrations of pollutants in Arctic ecosystems [85].

[xxxix] Alaskan Community Action on Toxics, Persistent Organic Pollutants in the Arctic http://www.ipen.org/ipenweb/documents/pop%20documents/cop4_pops_arctic.pdf

Ecosystem disturbance

As in the past, it is highly likely that future economic activity in the Arctic will further disturb ecosystems already stressed by the consequences of climate change. Migration patterns of caribou and whales in offshore areas may be affected. Other than the direct release of pollutants into the Arctic environment, there are multiple ways in which ecosystems could be disturbed:

- Through the construction of pipelines and roads [xl].
- Through noise pollution from offshore drilling, seismic survey activity or additional maritime traffic.
- Through physical disturbance of the sea and seabed during drilling.
- Through the break-up of sea ice.

Under national legislation in most Arctic countries a number of these factors must be included when making an environmental impact assessment of any development [xli], though the combined impact of developments will be far greater than those of any single project. But knowledge gaps are significant [86]. In combination with climate change, increased shipping in the Arctic is likely to increase the prevalence of invasive species, with major impacts on some Arctic ecosystems.

The Trans-Alaskan Pipeline.

[xl] The construction of the Trans-Alaska Pipeline, in particular, prompted a large number of environmental studies on the impact of the pipeline on migration routes. The design was altered to enable migration and the impact of the pipeline on migration has been substantially reduced as a result.
[xli] For an examples see the Arctic Environmental Impact Assessment http://arcticcentre.ulapland.fi/aria/

Pollution within the Arctic

There is a range of potential pollution sources within the Arctic, including mines, oil and gas installations, current industrial sites and, in the Russian Arctic, nuclear waste from both civilian and military nuclear installations, and from nuclear weapons testing on Novaya Zemlya. However, the risk of an oil spill, with multiple implications for the way in which oil and gas companies drill and operate in the Arctic, is probably the most relevant. It represents the greatest risk in terms of environmental damage, potential cost and insurance.

As discussed, many of the techniques for managing Arctic conditions, including ice, are neither new nor specific to the area north of 60°. Dynamic positioning drill ships or ice-resistant rigs and man-made islands have been used for some time, including in offshore Alaska in the 1980s and off Sakhalin. Location in the Arctic is only one risk factor for oil and gas development. The technical challenges of production in onshore or shallow-water offshore areas – and the associated risks of an oil spill – are no greater, and possibly far smaller, than in deep offshore areas anywhere else in the world. (In more remote and deeper parts of the Arctic the challenges are multiplied.)

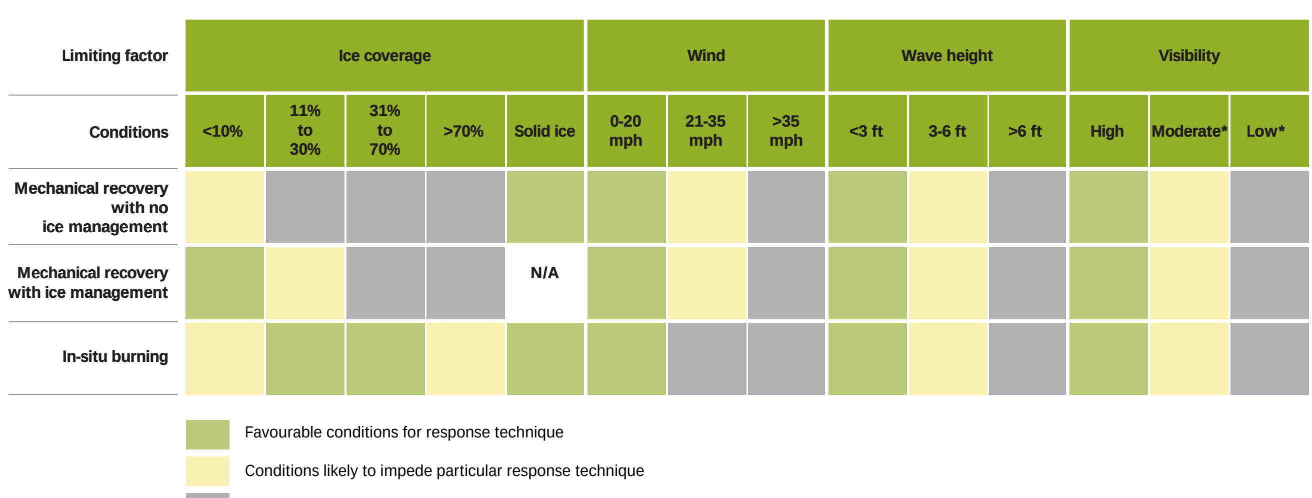
However, cleaning up any oil spill in the Arctic, particularly in ice-covered areas, would present multiple obstacles which together constitute a unique and hard-to-manage risk (see Figure 16). There are significant knowledge gaps in this area. Rates of natural biodegradation of oil in the Arctic could be expected to be lower than in more temperate environments such as the Gulf of Mexico, although there is currently insufficient understanding of how oil will degrade over the long term in the Arctic. The presence of sea ice could assist in some oil-spill response techniques such as in situ burning and chemical dispersant application. However, the techniques for keeping oil in one place have their own environmental impacts, notably air pollution and the release of chemicals into the marine environment without knowing where moving ice will eventually carry them [87].

3.3 Whose liability? Which liability regime?

The question of an appropriate liability regime for oil companies operating in the Arctic is contested amongst local populations, environmental campaigners, oil companies and central and federal governments.

Several international regimes govern liability for marine pollution caused by shipping [xlii]. There are well-established norms that provide for prompt compensation payments to victims for damage suffered in the territory of a state that is bound by the relevant treaties. Civil liabilities for shipowners are limited under these regimes to around

Figure 16. Different oil spill response techniques under a range of Arctic conditions



Note that any single grey factor could shut down a response. Similarly, a combination of yellow factors may have an aggregate impact on response.

* Moderate visibility = light fog < 1 mile visibility; low visibility = heavy fog <1/4 mile visibility, or darkness.

Source: Nuka Research and Planning Group, LLC and Pearson Consulting, LLC, 2010, Oil spill prevention and response in the U.S. Arctic Ocean – unexamined risks, unacceptable consequences, Report to the Pew Environment Group.

[xlii] These are: The 1969 International Convention on Civil Liability for Oil Pollution Damage (CLC) and the 1971 International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (Fund Convention); International Convention on Civil Liability for Bunker Oil Pollution Damage 2008.

The Exxon Valdez, disabled in Prince William Sound in 1989.

$139m[xliii], but an international fund accumulated from levies on oil cargo interests[xliv] can supplement compensation to a maximum of around $315m[88]. Environmental liability for shipowners is limited to economic losses caused by the pollution and the reinstatement of clean-up costs and only extends to damage in coastal state maritime zones.

These conventions have been evolving since 1969 and the trend is towards increasing liabilities and the scope for claims. For example, a further convention from the IMO on hazardous and noxious substances, not yet in force, covers risks to life and property beyond pollution and increases the coverage beyond oil to, for example, other liquids and solid materials possessing chemical hazards[89]. When this convention is enacted, shipowners from contracting party states will be liable to a maximum limit of 115 million Special Drawing Rights (SDR), currently $178 million[xlv].

At the time of writing, there is as yet no international instrument on liability and compensation resulting from spills from offshore oil rigs, pipelines and sub-sea wellhead production systems[90]. An EU proposal currently under discussion would apply to offshore oil projects in the Arctic territories of Norway and Denmark and possibly to all EU companies, wherever their operations. This would increase the companies' compliance requirements for both equipment standards and financial guarantees. An Arctic Council Task Force is developing recommendations on an international instrument on Arctic marine oil pollution, preparedness and response, due for release in 2013. This aims at developing a more streamlined process to ensure more rapid clean-up and compensation payments. Given the potential trans-national impact of spills, this may include an international liability and compensation instrument. Greenland, for example, has argued that "different national systems may lead to ambiguities and unnecessary delays in oil pollution responses and compensation payments" and that any regime must adapt as understanding of the 'worst-case scenario' in the Arctic changes[91].

The appendix illustrates the variety of national environmental regulations covering Arctic offshore operations. The inadequacies of both company and government capacities to act in the event of a disaster were demonstrated following the Macondo blowout in the Gulf of Mexico in April 2011. The Arctic's vulnerable environment, unpredictable climate and lack of any precedent on which to base cost assessment have led some environmental NGOs to argue that no compensation would be worth the risk of allowing drilling to take place in pristine offshore areas. Others are campaigning for more stringent regulations and the removal of liability caps for investors.

At the licensing stage, governments need to assure themselves of the capability of companies to prevent a blowout and, in the event that it occurs, the capacity to stop it quickly, contain it and clean up any oil leakage.

[xliii] International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage in 1992, based on the value of Special Drawing Rights (SDR) at 27 February 2012.
[xliv] Levies are calculated on the basis of the shipping company's national share of international oil receipts.
[xlv] SDRs are an international accounting unit.

Arctic conditions could present difficulties in reaching the site of a blowout and containing a spill. The Canadian National Energy Bureau's ongoing Review of Offshore Drilling in the Canadian Arctic (RODAC), for example, takes into account infrastructure gaps (eg coastguard facilities, dedicated emergency helicopters, booms, absorbents and skimmers) that would hinder the rapid distribution of oil-spill response equipment to the Beaufort Sea [92]. Companies drilling in offshore Canada must already have well-control technology installed and maintain the capacity to drill a same-season relief well (to mitigate the consequences of a blowout), despite the high costs this would impose on producers, potentially driving investors away [93]. New filing regulations released as part of the RODAC allow companies to waive this condition if they can prove the same containment impact by other methods. The Pew report cited above recommended that the US Government should require oil companies to demonstrate their containment capacity in test drills [94].

Whether the liability for damage to human health and economic losses should be limited or unlimited is an ongoing debate in Canada and the US. General 'unlimited liability' is often thought to create a risk too great for investors, although some may accept it for specific aspects such as the loss of current and future fishing harvest revenues [95]. Apart from the damage to local economies, ecosystem damage and degradation are notoriously difficult to put a value on and are not currently accounted for under national regimes. Some upper liability limits apply to companies operating facilities in offshore Alaska and Canada's eastern Arctic. The US Oil Pollution Act specifies a limit of US$75m for economic damages [xlvi], and the Canada Oil and Gas Operations Act of 1985 specifies CAN$40m for loss or damage, remediation and restoration [xlvii]. However, neither applies in cases of fault or gross negligence, where liabilities are unlimited. Norway, Greenland and Russia do not set upper limits for companies (see Appendix for more details).

Even though much greater claims can be pursued through the courts where fault can be established, some NGOs are arguing that the liabilities cap and extent of financial responsibility a company must demonstrate to win a lease put the public purse under enormous risk [96]. In allowing investors without sufficient funds to pay for the clean-up and reparations for a large-scale environmental disaster, the cap is essentially a transfer of risk to the public sector to encourage investment. In the US a company must demonstrate financial capability of up to US$150m. This is a fraction of the estimated US$40bn clean-up and compensation costs for the Macondo disaster. A smaller company than BP, for example, might have had to declare bankruptcy, leaving the state to foot the bill.

Financial capacity is an evolving area. The requirements are especially stringent in Greenland. In its 2010 Baffin Bay licensing round, the government, recognising the population's reliance on the local ecosystem for its livelihood, specified that companies must have at least $10bn of equity to qualify and that smaller companies winning exploration acreage would have to provide a $2bn bond to cover the clean-up costs of a spill. This would either involve a parent-company guarantee for the larger companies or be a straight advance at the time of the award [97].

In most cases, several companies will be involved – the concessionaires and the service companies – with various financial capacities and insurances. An efficient liability regime will help allow rapid identification of the responsible party and collection of compensation. In Norway, for example, the law clearly states that the licensee of a block is responsible for any pollution caused by operations there, regardless of fault. If a service company were at fault, the licensee would still be liable for all damages. They would have to pay out and then file a suit against the service company to recover its costs. This is in marked contrast to the US, which apportions responsibility to the entity owning the vessel or infrastructure from which pollutant was discharged. Companies will need to be aware of how binding agreements with the government would be if a major accident occurred, and of the potential for future international legislation – such as that proposed to the EU and to the Arctic Council – to override national jurisdictions.

As the appendix demonstrates, environmental regulation and liability in the Arctic are under scrutiny and subject to change. They will be shaped by public responses to recent and future cases of pollution, by evolving scientific understanding of Arctic ecosystems and by the domestic politics of the resource holders.

[xlvi] This limit is set by the US Oil Pollution Act of 1990 and does not apply to civil and criminal penalties under federal and state law, oil spill removal costs under federal law, or claims for damages brought under state law.
[xlvii] In Canada, higher amounts of liability could be sought under the Fisheries Act with the civil liabilities provisions not subject to any limitations. Amos and Daller, 2010.

box4: Arctic Drilling

As exploration for hydrocarbons moves into ever remoter regions of the Arctic, the harsh environment presents many challenges and risks for drilling operators. Maintaining well integrity is essential for drilling and producing operations. In the Arctic, drilling through permafrost in the rock can be challenging as the heat of the circulating drilling fluids (known as mud) can cause the permafrost to melt, removing the competency of the formations upon which the well foundations (casing and cements) rely, destabilising the well, and potentially leading to a blowout. During the producing phase the heat of the produced fluids can have a similar effect.

The difficulties involved in drilling in the Arctic may mean that summer drilling campaigns inadvertently last well into the more hazardous winter season. If a spill did occur in the Arctic, some commentators have suggested that there might be insufficient resources and equipment to stem an out-of-control well quickly [xlviii]. Icebreakers are in short supply, as seen by the difficulties experienced by the US Coast Guard in finding a suitable vessel to deliver an emergency shipment of fuel to an isolated community in Alaska in December 2011 [98]. There is also a shortage of Arctic-class mobile rigs capable of drilling relief wells in the event of a spill. The US administration's recent approval of Shell's plan to drill in US Arctic waters only went ahead following the submission of an emergency plan that included a fleet of 6 oil-spill response vessels,

[xlviii] BBC News (October 2011) Arctic oil exploration: Potential riches and problems http://www.bbc.co.uk/news/business-14728856

as well as a US Coast Guard vessel on standby near the rig at all times [99].

The harsh weather conditions in the Arctic raises questions over whether offshore drilling rigs can withstand its frequent severe storms. In December 2011, the Kolskaya floating drilling rig capsized and sank while under tow during a strong storm in the Sea of Okhotsk (just outside the 60° definition used by this report), killing 53 people [100] and causing an insurable loss of over $100 million [101]. The drilling rig was not carrying any oil when it sank, but there is concern that similar severe Arctic weather could destabilise other installations that store significant quantities of oil (such as FPSOs [xlix]), causing an environmental disaster [102]. The disaster also showed how cold waters dramatically reduce the chance of survival of any crew.

Damage caused by icebergs and offshore sea ice is a further risk for mobile drilling rigs and, with melting sea ice increasing the area of open waters, these rigs will need to cope with stronger waves. Various types of installations are used to drill in the Arctic, including drill ships, artificial structures and ice islands. Arctic drilling rigs are normally conical in shape at sea ice level and use steel plates that can be up to four inches thick to reduce the potential damage. Icebreakers are commonly used to break up the ice around the drilling installations and many operators employ data from ships and satellites to provide a real-time picture of sea ice movements [103]. Personnel employed as ice observers on all vessels associated with the drilling operations can also provide a more traditional source of information. However, employing rigs that can be disconnected and moved rather than those that are fixed in installation may reduce the likelihood of collision. Finally, double-hulled tankers are now the norm and are used to transport oil from the rigs and minimise the potential for pollution from a collision with an iceberg.

Technology adapted for the Arctic is already used in regions with similar conditions, including on Sakhalin Island. For instance, a FPSO vessel in Newfoundland has the capacity to disconnect the turret and mooring system from the vessel, leaving these parts submerged beneath the depth of the iceberg and allowing the vessel to be moved out of its path.

Some oil companies, notably Statoil, have raised the possibility of removing the need for surface vessels or equipment at all and conducting all drilling operations from the seabed [104]. Designs for Arctic-capable submarines are under way at the Norwegian Marine Technology Research Institute in Trondheim to replace the service vessels that are currently still required to perform maintenance on sub-sea installations. However, conducting operations on the seabed could mean that pollution spills go unnoticed for some considerable time. Those wishing to drill in the Arctic will be required to demonstrate that they have effective disaster management plans in place. In some jurisdictions this may be more onerous in the Arctic that elsewhere. The Canadian regulator has recently announced that all contractors will be required to have a contingency plan in place and has reaffirmed the requirement that companies have the capability to drill a relief well to stop an out-of-control well during the same drilling season [105].

Drilling systems and sub-sea pipelines are also at risk from submarine landslides and ice scours in the seabed. Mapping of the seabed of the Beaufort Sea has indicated unstable areas along the 50,000 square kilometres of the Beaufort continental shelf that could trigger potential landslides [106]. Arctic regions such as the Nunavut territory of Canada can also experience earthquakes which could damage onshore as well as offshore facilities [107]. Similarly, the Geological Survey has identified more than 17,000 known ice scours in water depths of 5–30 metres. Iceberg scouring that leaves these gouges can put immense pressure onto pipelines and sub-sea wellhead completions. Submerging them below the maximum depth at which these scours appear is not always sufficient as soil displacement following the movement of the ice can be equally disruptive to the pipeline.

[xlix] Floating Production Storage and Offloading unit. These vessels are designed to receive oil from nearby platforms or rigs, process the oil and then store it ready to be transported via tanker or pipeline.

box 5: Enhanced marine risks in the Arctic

Shipowners and shipping companies operating in the Arctic face a number of risks over and above the normal risks they would expect to face. First, there are increased risks to vessels owing to the remoteness, lack of infrastructure/support services and extreme weather conditions. Some of the factors, identified by the London market's Joint Hull Committee, are as follows [108]:

- Ice contact (including icebergs)
- Propeller, rudder and associated machinery damage from ice
- Grounding on uncharted rocks
- Icing (November to March)
- Fog (worst in June and July)
- Collision
- Delay/lack of salvage exacerbated by remoteness
- Lack of information about safe ports.

These risks will be exacerbated by a number of secondary factors, which include:

- Poor maps
- Poor hydrographic and meteorological data
- Poor satellite navigation information and communication problems.

Shipping companies will also face greater environmental risks owing to the potential impact of their activities and operations on the Arctic environment. As noted by the Arctic Marine Shipping Assessment Report 2009 produced through the Arctic Council: "Whether it is the release of substances through emissions to air or discharges to water, accidental release of oil or hazardous cargo, disturbances of wildlife through sound, sight, collisions or the introduction of invasive alien species, the Arctic marine environment is especially vulnerable to potential impacts from marine activity[109]." The potential impact was shown by the Exxon Valdez

Container ship navigating a frozen sea.

Clearing up in Prince William Sound after the Exxon Valdez spill in 1989.

disaster in 1989 that occurred just within the 60° north boundary of the Arctic used by this report. The resulting oil spill spread over 300 square miles, caused devastation to the pristine environment of Prince William Sound and cost Exxon $4.3bn in clean-up and compensatory costs [110].

The enhanced physical risks, together with the environmental risks, will lead to greater liability risks (and therefore potential liability costs) including pollution and third-party death or injury. For example, removing bunker fuel can be more challenging not only because of the extreme conditions, but also because the heavy-duty fuel used is potentially more polluting and ships may be carrying more fuel to enable them to trade in remote locations. Also repatriation costs for crew and passengers could be much higher in the Arctic.

A specific risk facing shipping companies is the lack of charts to support safe navigation. In its 2009 report, the Arctic Council highlighted that significant portions of primary Arctic shipping routes do not have adequate charts. This is most critical in the Canadian Archipelago and the Beaufort Sea, as well as in other areas including the Kara Sea, Laptev Sea and East Siberian Sea along the Northern Sea Route. The problems caused by lack of charts are exacerbated by the poor communications network in the region.

Cruise vessels present a particular challenge for shipowners, regulators and insurers in the Arctic. Specifically, larger cruise ships that are moved from the Caribbean, Europe or Mediterranean to operate in the Arctic represent a genuine challenge. In the Canadian Arctic during the summer of 2010 the Arctic expedition ship Clipper Adventurer grounded on a charted reef. The challenges for passenger rescue and salvage were clear, even though this was not an ice-related incident. Clearly there is a need for protocols and strategies within the cruise ship industry to tackle the enhanced risks in the Arctic.

3.4 Political and reputational risk factors

Many of the political and reputational risk factors associated with Arctic development are common across frontier developments. However, the political importance of the Arctic in domestic politics, the high international public profile of the Arctic region, and the region's environmental sensitivity could increase the potential impact of these risk factors. Levels of political risk vary widely across the region, depending on the stability of the rule of law and quality of the legal framework, the role of government bodies in shaping liabilities and influencing outcomes and the perceived likelihood of state appropriation. In Greenland, where oil and gas exploration has widespread public support, the political risks associated with development may be considered relatively low. In Russia, where appropriation of assets and political interference in commercial arrangements has affected oil and gas investments in the past, political risk is perceived to be much higher.

Reputational risk

The high-profile and controversial nature of Arctic developments attracts a degree of reputational risk to Arctic investments, even without any environmental or other harm being caused[i]. Should a problem occur, damage to a company's reputation is likely to extend far beyond the jurisdiction in which it occurs. Even if culpability or negligence cannot be legally proven, or if the fault is shown to lie with contractors or partners, the primary company's reputation is likely to be harmed. This could potentially result in closer scrutiny and political opposition to that company's role in other jurisdictions, as well as possible exclusion from the jurisdiction in which the event occurred. The social Arctic licence-to-operate is hard to win and easy to lose.

Companies investing in the Arctic should also be mindful of the reputational risks of being seen to benefit from the impacts of climate change, as once development is established in the Arctic it will become harder to take action to reverse the effects of climate change. With shareholders taking an increased interest in environment issues[ii], the decision to invest in the Arctic region may lead to greater shareholder scrutiny.

Regulatory and legal risk

In jurisdictions with high levels of litigation, court action can be highly effective in preventing or delaying drilling. In northern Alaska, litigation successfully prevented Shell from exercising its exploration rights under an offshore Arctic licence for several years.

[i] These reputational risks are widely recognised by companies operating in the Arctic and by governments.

[ii] See PWC report (2011), Shareholders press boards on social and environmental risks http://www.ey.com/Publication/vwLUAssets/CCaSS_social_environmental_risks/$FILE/CCaSS_social_environmental_risks.pdf

Given the sensitivity of Arctic development, there is greater risk from changes in regulation or investment frameworks, following either a change of political leadership or a specific risk event, even one in which the company is not itself implicated. The moratoria on Arctic drilling in the United States and Canadian Arctic following the Macondo disaster are a case in point. More broadly, a public and government reassessment of the balance between competing economic forces – such as between fishing and offshore oil and gas development – could provoke some regulatory shift.

Given the trans-border nature of potential environmental risk events, a company would have to consider not only the implications of a risk event in one jurisdiction, but also the possibility of the involvement of multiple jurisdictions.

Domestic political risk

Political support for Arctic development, particularly in the mining and oil and gas sectors, varies considerably between and within Arctic states. Levels of political support are generally high in Greenland. They are much lower in the US and Canada as a whole – though generally high in Alaska and in Canadian territories that stand to gain employment or revenue through development. In Russia, central government support is critical in order to create tax and incentive structures that encourage the national strategic priority of maintaining or expanding oil and gas exports. As anywhere in the world, Arctic projects ultimately depend on the support of the communities and countries in which they operate. Without this, development cannot take place.

In 2006 Royal Dutch Shell negotiated the rights to operate the Sakhalin II project to drill for hydrocarbons on the Russian-owned Sakhalin Island. However, Russian regulators then claimed to have found environmental inconsistencies that required the suspension of the project. It has been suggested that Shell was then put in a position whereby it needed to sell its majority stake in the project to Russian-owned Gazprom in order to “resolve” the environmental difficulties and to maintain the Shell license in the region [111]. Although Sakhalin is not located within the Arctic as defined by our report, the uncertain political and regulatory environment means that a previously agreed drilling licence could be confiscated in any number of the hydrocarbon fields in the Arctic region.

Geopolitical risk

Operations in the Arctic are exposed to the same range of political and geopolitical risks as in other parts of the world, including terrorism, though these are relatively much lower than in some frontier areas of development. For the foreseeable future, all offshore developments will take place in areas that are unlikely to be subject to territorial dispute between Arctic states.

However, in addition to the uncertainties outlined in section 2.5 there are a number of scenarios that could lead to dispute, drawing in or directly affecting private companies:

- If exploration licences were granted in the disputed areas of the Beaufort Sea, companies that began active drilling in that area could find themselves exposed to political disagreement between the US and Canada.
- If the Svalbard authorities allowed exploration and drilling for oil near the Svalbard archipelago on terms that signatories considered to be in breach of the Svalbard treaty, then geopolitical tensions might rise, with consequences for investors.
- In a situation of military tension between Arctic states, whether resulting from Arctic political disagreements or from a spillover from non-Arctic geopolitical competition, Arctic installations might be exposed.
- Terrorist actions could target Arctic installations with substantial commercial and environmental consequences.

However, at the time of writing, these are relatively unlikely scenarios. Managing and mitigating them depends on additional state surveillance of land, sea and air communication and co-operation between the military forces of Arctic countries, adequate constabulary capability across the Arctic, a clear understanding between Arctic states of the scale and role of military forces and, in extremis, sufficient military forces to protect economic assets.

For Arctic shipping the political and geopolitical risks are somewhat different. Disagreement over the legal status of the Northwest Passage and potentially over the status of Russian Arctic waters could lead to claims that double standards are being applied, or to claims of a contravention of the Law of the Sea (LOS) provisions, including those relating to “ice-covered waters” [112]. To the extent that Arctic states – particularly Canada and Russia – seek to apply special regulations on shipping in the Arctic, above and beyond any internationally agreed conventions, there is scope for disagreement [lii].

[lii] This would include regimes such as the Canadian Arctic Waters Pollution Prevention Act (AWPPA) which place additional requirements on shipping in Arctic Waters.

3.5 Managing risk

Given the complex and often unique risk challenges of the Arctic described above, all interested parties need to adopt a cautious and highly risk-aware approach to Arctic development.

Governments – singly and together – have an essential role in setting acceptable risk thresholds, monitoring activity and ensuring that knowledge gaps are sufficiently addressed. They will need to ensure that an integrated ecosystem-based approach is taken to development, to avoid the impacts of one activity harming and displacing others. They will also need to take full account of the cumulative impacts of development, as opposed to the impacts of a single project. Governments should insist upon a safety-case, rather than a prescriptive, approach to risk management [liii].

Where activity takes place, corporate risk management is fundamental for companies to work safely, sustainably and successfully. As this report has emphasised, there is a wide range of Arctic operating environments that present greater or lesser operational and other risks, but many parts of the Arctic remain extreme. Practices and technologies will need to be continuously updated to reflect a rapidly changing situation, and to ensure that best practice is constantly improved and consistently applied.

Though much research is ongoing and experience from outside the Arctic region may prove useful to operations within it, considerable further research and analysis are required to fully assess the range of hazards of Arctic operations and the vulnerabilities of technical systems, equipment and the Arctic environment to disruption and harm.

Below we consider the main risk management approaches – risk governance, risk mitigation and risk transfer – principally from a corporate perspective, and principally with relevance to the oil, gas, mining and logistics sectors [liv].

3.5.1 Risk governance

Firms arguably do not need to recreate their risk management frameworks for the Arctic context. They will need to ensure, however, that these frameworks take account of the complex and fast-changing nature of the Arctic risk environment.

Company boards need to be fully engaged in the risk management process and to ensure that a risk culture is embedded across the organisation, from business planning to clear communication of risk issues. Governance frameworks should include clear procedures for risk identification, assessment and analysis, and control, as well as action planning and reporting.

Companies also need to think through possible worst-case scenarios and develop plans both to prevent these occurring, and to respond if the worst did happen. These plans should include clear and robust action plans for crisis management as well as strategies and approaches to manage any reputational damage.

Greenland's frozen landscape.

[liii] A safety-case approach involves management presenting information showing that it has considered all risks relevant to its specific operation and has detailed how it will avoid or manage these risks. This is in contrast to a prescriptive regime where regulators define what operators must do to comply and there is no requirement for management to do more than what is prescribed.

[liv] Much of the material in this section is derived from risk experts within the Lloyd's market.

While management of reputational risk necessarily remains the exclusive responsibility of companies themselves, crisis-management plans for Arctic operations should be either available to public authorities or published to ensure public oversight, maintain public trust, and make companies fully accountable for their actions.

3.5.2 Risk mitigation

There are a number of ways in which companies can mitigate some of the risks of operating in the Arctic. Many of these will be techniques and approaches adapted from other regions, particularly those where extreme cold conditions are the norm. However, some will be unique to Arctic conditions.

The development and implementation of best-in-class safety and operational standards at both corporate and industry-wide level are crucial. The development of ISO standards – such as ISO 19906: 2010 covering Arctic offshore structures for the oil and gas industry, and the development of an IMO polar shipping code – are good examples of this. While learning from experience elsewhere, these reflect the complexity and sensitivity of the Arctic risk environment.

Offshore, there are a number of practical operational steps and actions that companies operating in the Arctic can take to mitigate risk. Ice preparedness and ice management – from ice-drift maps to satellite tracking – are key. There are also various practical actions that energy and shipping companies can take once operations are under way, including detection of icebergs by radar, aerial and vessel reconnaissance, icebreaker support and physical management in the form of towing vessels out of danger or using water cannons.

Companies can also mitigate risks by adopting the latest, Arctic-specific technologies, materials and processes, including drill rigs and the latest ice-class vessels. Indeed, some of the extreme environmental factors experienced in the Arctic can be mitigated through the design process.

Finally, as mentioned earlier, if all the above fails, companies must develop response plans for the full range of hazard events, including under-ice blowout and pollution.

3.5.3 The role of risk transfer

While corporate risk management in the Arctic should focus on risk mitigation, any robust and comprehensive risk management strategy should also consider transferring some risks to a third party through insurance. A number of specialist insurers have provided insurance cover in extreme conditions, including the Arctic. Insurance should not only be seen as financial protection. Rigorous insurance processes can promote improved risk management within a company, reducing risk before the event as well as managing the cost of actual risk events to a company.

We briefly outline the current outlook for insurance in three main areas – marine insurance, energy industry insurance and political risk.

Marine insurance

The maritime insurance industry can play a critical role in reducing risk for shipping companies in the Arctic, as elsewhere. If insurers are unable to cover shipping through the Arctic, or if rates for insurance cover are exceptionally high, the economic viability of some Arctic shipping may be brought into question. This has broad implications for other industry sectors reliant on maritime logistics – including natural resource development.

Insurers are currently helping to improve the safety and raise awareness of the Arctic shipping routes, by providing information and encouraging effective risk-mitigation measures and safer vessels. The website of the London market’s Joint Hull Committee (JHC), Navigating Limits Sub-Committee is a good resource for shipping companies

An icebreaker creates a channel.

and insurers operating in the Arctic with wordings, recent incidents, links and ice maps[113]. Though commercial maritime interest in the Arctic is growing, the current take-up of Arctic specific insurance is currently limited by the relatively small numbers of vessel voyages per year.

The key issues of concern for underwriters when considering the Arctic are: remoteness, lack of rescue and salvage facilities, whether a vessel to be insured is sufficiently ice-classed for expected conditions and whether it will receive icebreaker support. The JHC highlighted the need for underwriters to satisfy themselves on the following points, as a minimum:

- Voyage feasibility study, including ports of refuge.
- Suitability of the vessel for the intended voyage.
- Proposed route, dates and timing.
- Crewing arrangements including key personnel's levels of experience in Arctic navigation[lv].
- Icebreaker and/or escort arrangements.
- Access to accurate and up-to-date weather/ice information during the voyage.
- Assessment of chart accuracy.
- Whether an ice pilot will be on board.
- Bunkering arrangements.

The main types of insurance for vessels in the Arctic are Hull (including Increased Value[lvi]), Cargo and P&I (Marine Liability):

- There is likely to be an additional Arctic premium for hull insurance and/or an additional voyage-specific ice deductible, based on a loading of the standard annual Navigating premium for a particular time period (such as the length of the voyage). The ability to insure will depend on how far the responses to the points above satisfy Hull underwriters.
- The market will not charge additional premiums for cargo for Arctic trade under a worldwide policy. For a specific cargo, perceived additional Arctic exposure is likely to be taken into account in the original rating.

Bow of an icebreaking vessel.

[lv] The JHC also advise that it can be helpful for ships using the Northern Sea Route to have a Russian-speaking desk officer on board.

[lvi] This is a separate product written in the hull market, which covers assets other than hull itself such as bunkers.

Oil worker on a Russian drilling rig.

- The potential costs of Marine Liability risks – wreck removal, pollution, and death and bodily injury to passengers and crew – will be enhanced and are likely to be much more severe events in the Arctic owing to the remote and harsh environment [lvii].

Insurance for the energy industry

Insurance is currently provided for a range of risks within the energy industry, from physical loss and damage to property, removal of wreck and evacuation expenses, business interruption and loss of production income, liabilities for death and bodily injury to employees, third parties and third-party property damage and construction risks.

Insurance is also provided for Control of Well and a range of Operators' Extra Expenses (OEE) with relevance to the Arctic offshore, in particular:

- Covering a blowout that requires control to be regained. This may include expenditures for hiring mobile drilling rigs to drill relief wells. In Canada, operators are required to have a second mobile drilling rig standing by, greatly increasing the cost.
- Re-drilling or extended re-drilling of wells, making them safe or plugging and abandoning them.
- Covering seepage and pollution, essentially from a blowout, though it has been possible to extend cover to include pollution from the production facility itself, provided the original cause of loss is a blowout. The agreement covers legal liability, the costs of clean-up (whether or not there is legal liability) and legal defence costs [lviii].

As with maritime cover, insurance capacity for the energy industry is not unlimited. Cover is offered for risks in return for appropriate premiums and on specified terms and conditions [114]. Areas of cover may clash, and insurers will have their own maximum limits for which they will offer capacity [lix]. There may be many parties involved in a drilling operation, from the operator (and any joint operators) to the service companies, contractors and equipment providers (including the provider of a blowout preventer). Insurers may be covering several of these parties and will therefore need to manage any potential aggregations of risk. Geographic aggregation of risks can also occur if limited accessibility in the Arctic forces companies to focus operations in one place, for instance through the use of extended reach wells [lx]. Managing risk in the offshore Arctic and insuring it is likely to be costly. Risk criteria will be set much higher than in other offshore areas, such as the

[lvii] The International Group of P & I clubs (IGA) are a pool that retains the first layer of marine liability losses (currently $60m), with the excess being placed as reinsurance in several insurance markets, and led in Lloyd's. There is insurance in place for up to $1bn for pollution and $3bn for death and bodily injury to passengers and crew.

[lviii] The insured has autonomy to act quickly to try to prevent pollution reaching the shore.
[lix] Clashing exposures include physical loss and damage to assets such as platforms or mobile rigs, control of well, and operators' extra expense and pollution liability.
[lx] Extended reach drilling refers to the directional drilling of very long horizontal wells.

North Sea, as the consequences of an event could be much worse. Lower risk criteria would reduce operational costs for energy companies, but increase the risk to insurers.

Cover provided by a typical OEE policy

- Control of well: this is effectively a blowout, requiring regain of control, and may, at worst, include costs for hiring mobile drilling rigs to drill relief wells.
- Re-drill: typically this follows a blowout; when a well is brought under control it may need to be re-drilled, or restored to its condition prior to the blowout. The costs incurred are in respect of re-drilling to the depth at which control was lost.
- Extended re-drill: this covers costs to re-drill or restore wells that have been lost as a result of damage to production infrastructure.
- Making wells safe: this relates to a physical loss or damage to the platform and involves sub-surface activity to make the well safe.
- P&A: the requirement to plug and abandon a well could result from physical loss or damage to the platform.
- Seepage and pollution: coverage under the policy is triggered by pollution from wells resulting from blowouts, and not pollution from other facilities and resulting from other causes. The insuring agreement is in three main parts:
    1. Legal liability, or liability incurred under a lease block contract, for damages in respect of third-party property damage and injury.
    2. Costs incurred by the insured to clean up, or attempt to clean up, seeping, polluting and contaminating substances. This second part does not require legal liability. The insured has autonomy to act quickly to try to prevent pollution reaching the shore.
    3. In addition the policy covers legal defence costs.

These coverage provisions are based on a pollution incident that is sudden and accidental and for which notice provisions are incorporated into the policy.

Political risk

A company may invest in the Arctic economy only to find that its investment is threatened owing to changes in commercial interests, regulatory obstacles or political change. It may be possible to transfer these risks to the insurance market through specialist political risk products.

Two main groupings back up this class; Contract Frustration and Confiscation, Expropriation and Nationalisation (CEN)

- Most standard commercial property covers exclude damage following government actions. CEN can fill this gap and protect companies from financial loss, perhaps following the passage of new laws that make the operating environment unviable, following destruction of assets by the state and confiscation, or following government expropriation and nationalisation. When there are a series of acts by the government that slowly ensures deterioration in the operating environment this can also be included in cover and is often referred to as "creeping expropriation".

- In the Arctic, due to the geopolitical dynamics of the region, coverage for war, terrorism and forced abandonment can be added to a CEN policy. Forced abandonment cover ensures the insured is protected against a situation where the security environment deteriorates and it becomes no longer safe to operate with the Insured abandoning their property. A third party analyst is often required to confirm that this is the case and the property will have to be abandoned for a continuous period of 180 days for a claim to be paid.

- Some insurers offer contract frustration cover, which provides coverage for a loss under a contract or agreement following a political event beyond the control of the insured. A sovereignty dispute leading to the invalidation of a previously purchased offshore drilling licence would be considered an insurable risk under a contract frustration policy. Coverage could also extend to ensure an indemnity is paid if the royalties or taxes are amended. Environmental issues, however, might be excluded. Unfair and/or politically fair calling of bond cover is often added as an extension to contract frustration if the contract is especially large.

With all these products, it is usual for the insurer to require evidence from the insured that they have authorisation for their licenses to operate in the region. Political risk insurance also relies on clear ownership of assets and contracts. To the extent that there may be legal uncertainty around the final position of sovereignty over some parts of the Arctic, underwriters will likely be reluctant to offer cover.

4. CONCLUSIONS

- Investment in science and research – both by government agencies and by private companies – is essential to close knowledge gaps, reduce uncertainties and manage risks. Arctic economic development can only proceed at a rate that takes into account these factors, that can be measured against environmental baselines and that recognises the primary role of governments in setting frameworks and establishing public policy priorities. Further research is required to ensure future development takes place sustainably and does not cause irreparable damage to the environment.

- Major investment is required in infrastructure and surveillance to enable safe economic activity. In many areas – shipping, search and rescue – infrastructure is currently insufficient to meet the expected demands of economic development. Public/private co-operation is needed to provide this infrastructure.

- Full-scale exercises based on worst-case scenarios of environmental disaster should be run by companies with government involvement and oversight to provide a transparent account of the state of knowledge and capabilities, to foster expertise and to assuage legitimate public concerns.

- Companies have a responsibility and interest in establishing industry-wide standards and expectations for safety and stewardship, through the Arctic Council, through the International Maritime Organisation or through industry associations. Failure by one company will have impacts for others.

- Integrated ecosystem-based management, incorporating the full range of economic factors, is needed in order to avoid one activity harming and displacing others and to take full account of the cumulative impacts of development. Long-term viability should be a key policy consideration for governments, business and other stakeholders.

- The mosaic of regulations and governments in the Arctic creates a multi-jurisdictional challenge for investment and operations in the Arctic. Working through the Arctic Council to promote high and common regulations for Arctic economic activity is key. Both domestic legislation and international agreements should adopt a safety-case analysis rather than a prescriptive approach to risk management. States should provide strong and transparent oversight through appropriate government agencies, aligning risks and incentives for private companies with the broader public interest, and ensuring that private economic interests do not overcome legitimate public concerns.

- Governments should be clear about the purpose and scope of military activities in the Arctic, so as to prevent misunderstanding or miscalculations from developing. At the same time, additional state policing capacity in the Arctic – to police and protect – should be broadly welcomed.

- Given the extreme and fast-changing risks facing companies in the Arctic, robust risk management approaches will be vital to allow sustainable economic development and to ensure that all stakeholders can benefit from economic opportunities. In addition to embedding a risk culture throughout the organisation, adopting best practice standards and implementing practical risk mitigation measures, any comprehensive risk management approach is likely to consider transferring risks as a key part of the strategy.

appendix

ENVIRONMENTAL REGULATION OF ARCTIC OFFSHORE OIL AND GAS ACTIVITIES

	Russia	Norway	US	Canada	Denmark & Greenland	Iceland
State body	Ministry of Natural Resources and Environment (MNRE) Rosnedra (federal agency for subsoil usage) Rosprirodnadzor (federal service for supervising of the use of natural resources)	Norwegian Ministry of the Environment (MD) Norwegian Climate and Pollution Agency (Klif) Norwegian Ministry of Health and Social Affairs (SHD) Norwegian Pollution Control Authority (SFT) Norwegian Petroleum Directorate (NPD)	Department of the Interior (DoI) Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) Bureau of Safety and Environmental Enforcement (BSEE) US Environmental Protection Agency (EPA)	National Energy Board (NEB) Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) Aboriginal Affairs and Northern Development Canada (AANDC)	BMP, GINR, NERI, DNEI Bureau of Minerals and Petrol (BMP) Greenland Institute for Natural Resources (GINR) National Environmental Research Institute (NERI)	National Energy Authority (NEA) Ministry of Industry, Energy and Tourism (MoIET)
Regulatory approaches	Strict environmental codes; though historically irregular application. Concerns about politicisation of enforcement.	On-going comprehensive environmental regulation and obligatory Environmental Impact Assessments. Aims to balance interests of fisheries and oil and gas sectors. CO2 emissions tax.	Sector- and objective-specific mandates within a 'culture of safety'. Incorporation of industry standards advised where regulatory requirements are imprecise.	Case-by-case consideration of each company's safety plan.	Integrated process incorporating 'dynamic interpretation' of Mineral Resources Act. Burden of proof on investor to demonstrate adherence to international best practices.	Standards set by MoIET on a case-by-case basis. Obligatory Special Safety Zone around all offshore installations.
Investor obligations	MNREP's approval of project's Environmental Impact Assessment	Authorization of Compliance on technical and management capacities, Environmental Impact Assessment, emergency preparedness report. Seasonal restrictions may apply according to spawning and migration periods.	Multidimensional, implementation and on-going revision of Safety and Environmental Management System and emergency preparedness report. Plan of Co-operation with indigenous communities, 8% tax/barrel paid into Oil Spill Liability Trust Fund. Company must demonstrate financial capability of up to $150m	Emergency preparedness report, Certificate of Fitness per installation. Proven capacity to drill same-season response well. Exemption allowed for companies that can demonstrate ability to achieve intended outcome by alternative means per 2011 NEB review.	To be awarded an exploration licence, company must have equity of at least US$10bn. Guarantee of financial responsibility in the form of bond or insurance certificate. Certification of fitness per installation and vessel, documented management capabilities, Environmental Impact Assessment and Social Impact Assessment EIA and public announcement of their results.	
Liability regimes	Unlimited liability; civil, administrative and/or criminal. Non-compliance can lead to fines or suspension of operations at the discretion of independent inspector.	Unlimited liability. In event of pollution damage, licensee liable to those affected without regard to fault. Liability can be reduced if force majeure event contributed. Claims can be pursued through district courts. Special compensation allowed for Norwegian fishermen.	Civil and criminal liability; offshore spill liability capped at $75m/incident unless fault or gross negligence established. Not applicable to regulatory violations or claims for damages brought under state law. Ascription of liability ambiguous.	Liability capped at CAN$40m unless fault or negligence is established. Fisheries Act can also apply. Civil damages have no upper limit.	Unlimited liability, even in "accidental" cases. Compensation calculated proportionate to event.	Details unclear. Operator or licensee may be held liable, regardless of whether loss or damage was caused by culpable conduct or not. Act of God or war exempted.
Current status	Federal Law on the Russian Arctic Zone 2012 to identify Arctic territories as unique objects of state policy regarding socio-economic and environmental legislation; new Russia-Norway collaborative partnership launched in 2012, to include an environmental working group. Greater public objections to sub-sea drilling in Arctic following sinking of offshore platform in the White Sea in May 2011.	30-year moratorium on oil production in the Lofoten, Vesteraalen and Senja islands in the Norwegian Sea extended until 2013. Contested issue domestically.	Moratorium post-Macondo eased in August 2011 as conditional approval granted to a couple of IOCs. Environmental challenges delaying and/or complicating operations in Beaufort and Chukchi Seas, including DoI's listing of the polar bear as an endangered species. Next round of leases scheduled for 2015/16, pending Environmental Impact Assessments and infrastructure assessments; currently area-wide but BOEMRE developing leasing system specific to local environmental conditions.	Currently no offshore drilling; NEB conducting a post-Deepwater Horizon review of licensing requirements. New filing requirements released December 2011, which also pertain to companies already holding licences in the Beaufort Sea. New management tool (Petroleum and Environmental Management Tool) mapping ecological and social parameters introduced by AANDC in 2009 to improve future consultation process.	Governments working within the Arctic Council to support an international instrument for offshore oil exploration/exploitation liability and compensation.	There are currently no companies with exploration and production licences on the Icelandic Continental Shelf. A second licensing round opened in October 2011.

Sources: Alaska Offshore, The Arctic Council, Barents Observer, Bellona, BMP (Denmark) BOEMRE (US), Goltsblat BLP, Government of Greenland, International Law Office, Oil and Gas Journal, MNRE (Russia), NEB (Canada), NPD (Norway), NRCan (Canada), The Pembina Institute, Tulane University, University of Ottowa-Ecojustice Environmental Law Clinic, Vermont Law School.

REFERENCES

1 See, for example, E. Goodstein, E. Euskirchen and H. Huntington, An Initial Estimate of the Cost of Lost Climate Regulation Services due to Changes in the Arctic Cryosphere, Pew Environmental Group, February 2010 and David Leary, Bioprospecting in the Arctic, United Nations University Institute of Advanced Studies, 2008.

2 For the most comprehensive and most recent overview of Arctic environmental change see the Arctic report card produced annually by the United States' National Oceanic and Atmospheric Administration. The most recent report card, published in November 2011, is available at: http://www.arctic.noaa.gov/reportcard/

3 James Overland, 'Atmosphere Summary', Arctic Report Card, NOAA, November 2011. The 1961–1990 baseline was some 0.77°C colder than the 1981–2010 baseline. The 1.5°C figure quoted here is not the same as the Met Office figures represented in Figure 2, which corresponds to the 1961–1990 baseline, and to an annual rather than monthly calculation.

4 See Kevin R. Wood, James E. Overland, Trausti Jónsson and Brian V. Smoliak, 'Air temperature variations on the Atlantic Arctic boundary since 1802', Geophysical Research Letters, Vol. 37, 2010 and T. V. Callaghan, F. Bergholm, T.R. Christensen, C. Jonasson, U. Kokfelt and M. Johansson, 'A new climate era in the sub-Arctic: Accelerating climate changes and multiple impacts', Geophysical Research Letters, Vol. 37, 2010.

5 P. Brohan, J.J. Kennedy, I. Harris, S.F.B. Tett and P.D. Jones, Uncertainty estimates in regional and global observed temperature changes: a new dataset from 1850. J. Geophys. Res, 111, D12106, doi:10.1029/2005JD006548. Contains public sector information licensed under the Open Government Licence v1.0.

6 J. Overland, U. Bhatt, J. Key, Y. Liu, J. Walsh and M. Wang, 'Temperature and Clouds', Arctic Report Card, NOAA, November 2011.

7 See Charles Wohlforth, The Whale and the Supercomputer: On the Northern Front of Climate Change, 2005.

8 Full data available at: http://nsidc.org/arcticseaicenews/2011/10/

9 Data available here: http://www.iup.uni-bremen.de:8084/amsr/#Arctic

10 The data and methodology of the PIOMAS team at the University of Washington can be found here: http://psc.apl.washington.edu/wordpress/research/projects/projections-of-an-ice-diminished-arctic-ocean/

11 A. Schweiger, 2011. Arctic Sea Ice Volume Anomaly, Version 2. Seattle, WA: Polar Science Center, Applied Physics Laboratory, University of Washington Data set accessed February 2012: http://psc.apl.washington.edu/wordpress/research/projects/arctic-sea ice-volume-anomaly/ and A. Schweiger, R. Lindsay, J. Zhang, M. Steele, H. Stern, and R. Kwok, Uncertainty in Modelled Arctic Sea Ice Volume. Geophys. Res., doi:10.1029/2011JC007084, 2011.

12 P. Rampal, J. Weiss, C. Dubois and J.-M. Campin, 'IPCC climate models do not capture Arctic sea ice drift acceleration: Consequences in terms of projected sea ice thinning and decline', Journal of Geophysical Research, Vol. 116, 2011.

13 K.E. Frey, K.R. Arrigo and R.R. Gradinger, 'Arctic Ocean Primary Productivity', Arctic Report Card, NOAA, November 2011.

14 J. Mathis, 'The Extent and Controls on Ocean Acidification in the Western Arctic Ocean and in the Adjacent Continental Shelf Seas', Arctic Report Card, NOAA, November 2011.

15 See, for example, Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability, Intergovernmental Panel on Climate Change (IPCC), 2007.

16 See Marta Bristow and Vijay Gill, Northern Assets: Transportation Infrastructure in Remote Communities, Conference Board of Canada, December 2011.

17 See L.D. Hinzman et al., 'Evidence and implications of recent climate change in northern Alaska and other Arctic regions', Climate Change 72, pp. 251–298, 2005.

18 For a discussion of these issues, see Cleo Paskal, Global Warring: How Environmental, Economic and Political Crises will Redraw the World Map, London, 2010, pp. 1–75.

19 I. Overeem, R.S. Anderson, C. Wobus, G.D. Clow, F.E. Urban and N. Matell, published online 2011. Sea Ice Loss Enhances Wave Action at the Arctic Coast. Geophysical Research Letters, 38, L17503, doi:10.1029/2011GL048681, 2011.

20 M.C. Mack, M.S. Bret-Harte, T.K.N. Hollingsworth, R.R. Jandt, E.A.G. Schuur, G.R. Shaver and D. L. Verbyla, 2011, Carbon loss from an unprecedented arctic tundra wildfire. Nature 475: 489–492.

[21] See, for example, Arctic Report Card 2011, NOAA; Sirpa Hakkinen, Andrey Proshutinsky and Igor Ashik, 'Sea drift in the Arctic since the 1950s' Geophysical Research Letters, Vol. 35, 2008; Erik W. Kolstad and Thomas J. Bracegirdle, 'Marine Cold-Air Outbreaks in the Future: An Assessment of IPCC AR4 Model Results for the Northern Hemisphere', Climate Dynamics, 2008, Vol. 30, pp. 871–885.

[22] Jiping Liua, Judith A. Currya, Huijun Wangb, Mirong Songb, and Radley M. Horton, 'Impact of declining sea ice on winter snowfall', Proceedings of the National Academy of Sciences of the United States of America, 27 February 2012.

[23] See data from GRACE satellite, available at http://grace.jpl.nasa.gov/news/

[24] E. Rignot, I. Velicogna, M.R. van den Broeke, A. Monaghan and J. Lenaerts, 'Acceleration of the contribution of the Greenland and Antarctic ice sheets to sea level rise', Geophysical Research Letters, 38, 2011.

[25] Box JE, Cappelen, J., Chen, C., Decker, D., Fettweis, X., Hall, D., Hanna, E., Jørgesnsen, B. V., Knudsen, N. T., Lipscomb W.H., Mernild, S. H., Mote, T., Steiner, N., Tedesco, M., van de Wal, R. S. W., Wahr, J., 'Greenland ice sheet', Arctic Report Card, NOAA, November 2011.

[26] M. Tedesco and N. Steiner, City College of New York; X. Fettweis, University of Liege, Liege, Belgium; T. Mote, University of Athens, Georgia, US and J. E. Box, Byrd Polar Research Center, The Ohio State University, Columbus, Ohio, US.

[27] Jeff Ridley, Jonathan M. Gregory, Philippe Huybrechts, Jason Lowe, 'Thresholds for irreversible decline of the Greenland ice-sheet', Climate Dynamics, 35, 2010.

[28] See footnote ii.

[29] For a history of the Arctic oil and gas industry, in the context of the global oil and gas industry, see Charles Emmerson, The Future History of the Arctic, Random House, 2010.

[30] Bird, Kenneth J., Charpentier, Ronald R., Gautier, Donald L., Houseknecht, David W., Klett, Timothy R., Pitman, Janet K., Moore, Thomas E., Schenk, Christopher J., Tennyson, Marilyn E. and Wandrey, Craig J., Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle, USGS Fact Sheet 2008-3049, 2008. The total natural gas estimate was 1,668,657.84 billion cubic feet, equivalent to approximately 278 billion barrels of oil. There was, additionally, an estimate of 44 billion barrels of natural gas liquids.

[31] See, for example, the USGS Circum-Arctic Resource Appraisal, 2008.

[32] The actual number was 945 million standard cubic metres of oil equivalent (scm oe) ranging from 175 million scm oe to 2,460 million scm oe. Norwegian Petroleum Directorate, Petroleum Resources on the Norwegian Continental Shelf, 2011.

[33] 'Major New Oil Discovery in the Barents Sea', Statoil, 9 January, 2012, available at www.statoil.com/en/NewsAndMedia/News/2012/Pages/08Jan_Havis.aspx

[34] See, for example, 'Ricardo study suggests global oil demand may peak before 2020', Ricardo Strategic Consulting, November 2011.

[35] Paul Stevens, The Coming Oil Supply Crunch, Chatham House Report, 2008.

[36] 'BP, ConocoPhillips Halt Proposed $35 Billion Alaska Gas-Pipeline Project', Bloomberg, 17 May 2011. Attention is now likely to turn to the prospect of exporting Alaskan LNG to Asia.

[37] World Energy Outlook 2008 © OECD/International Energy Agency 2008, figure 9.10, page 218

[38] World Energy Outlook 2011, International Energy Agency (IEA), 2011.

[39] 'Shtokman gas condensate deposit: Russian Federation', Offshore Technology, http://www.offshore-technology.com/projects/shtokman/

[40] For more information on Yamal project, see http://www.gazprom.com/about/production/projects/mega-yamal/

[41] See, for example, 'Investment in the Yamal LNG project estimated at $18-20 billion by 2018', Oil of Russia, 24 June 2010 and Anna Shiryaevskaya, 'Novatek Will Lead Gazprom in Putin's LNG Push After $4 Billion Total Deal', Bloomberg, March 9, 2011.

[42] TNK-BP, LUKOIL and Gazprom Neft have agreed to invest some $2 billion in Transneft's construction of a 12mt/y oil pipeline from Yamal Nenets to China in return for discounts on crude transports eastward. 'New Pipeline Planned from Yamal to China', Reuters, 8 September 2010.

[43] 'Exxon and Rosneft sign Arctic Deal', Financial Times, 30 August 2011.

[44] Norwegian Petroleum Directorate. Available at: http://www.npd.no/en/Publications/Facts/Facts-2011/Chapter-11/Goliat/

[45] 'Major New Oil Discovery in the Barents Sea', Statoil, 9 January 2012. http://www.statoil.com/en/NewsAndMedia/News/2012/Pages/08Jan_Havis.aspx

[46] 'Study lists Alaska Arctic OCS development's potential benefits', Oil and Gas Journal, 24 February 2011.

[47] 'Nunaoil's Role as a National Oil Company', presentation by Hans Kristian Olsen, Offshore Greenland Conference, Sisimiut, 30 April – 1 May 2011 http://www.offshoregreenland.com/6_NUNAOIL%20Offshore%20Greenland%20Sisimiut.pdf

[48] See, for example, Mineral Resources of the Russian Shelf, Geoinformark, 2006.

[49] US Census Bureau, State exports for Alaska. Oil and gas production is a far more substantial employer overall, but most oil and gas is consumed domestically, within the United States, and therefore does not appear in foreign export earnings figures. http://www.census.gov/foreign-trade/statistics/

[50] Mining Journal (September 2010) Greenland amends law to allow uranium mining http://www.mining-journal.com/exploration--and--development/greenland-amends-law-to-allow-uranium-mining

[51] For data on the Canadian mining sector, see: http://www.nrcan.gc.ca/earth-sciences/home

[52] Diavik Diamond Mine Factbook, Rio Tinto, 2008.

[53] Eric C. Howe, The Economic Impact of the Mary River Project on Nunavut and the provinces of Canada, September 2010, Appendix 4b to Baffinland Environmental Impact Assessment. In sub-Arctic northern Quebec the "Plan Nord" development initiative – covering mining and hydropower – is anticipated to require tens of billions of dollars of investment, which may subsequently provide a basis for further northern development.

[54] See, for example, Morten C. Smelror, Mining in the Arctic, presentation, Arctic Frontiers conference January 2011.

[55] See, for example, Bettina Rudloff, 'Fisch im Wasser?: Die EU and die Arktisfischerei', OstEuropa, 2011.

[56] Bettina Rudloff, The EU as a Fishing Actor in the Arctic: Stocktaking of Institutional Involvement and Existing Conflicts, Stiftung Wissenschaft und Politik, July 2010.

[57] The figures were 11.2 billion NOK and 29.2 billion NOK respectively.

[58] See Frédéric Lasserre, 'Arctic Shipping – The Ships will Come, but Not for Transit', Baltic Rim Economies, Quarterly Review 4, 2011.

[59] Greenland Statistical Yearbook 2010, available at: www.stat.gl

[60] See D. Zeller, S. Booth, E. Pakhomov, W. Swartz, D. Pauly, 'Arctic fisheries catches in Russia, USA and Canada: baselines for neglected ecosystems', Polar Biology, October 2010.

[61] CAFF, available at www.caff.is

[62] Arctic Marine Shipping Assessment 2009 (AMSA), Arctic Council.

[63] Charles Ebinger and Evie Zambetakis, The Geopolitics of Arctic Melt, Brookings Institution, 2009, available at www.brookings.edu

[64] The Arctic Institute (September 2011), The Future of the Northern Sea Route - A "Golden Waterway" or a Niche Trade Route, http://www.thearcticinstitute.org/2011/10/future-of-northern-sea-route-golden_13.html

[65] Lloyd's Register (January 2011) Steen Hashold, CDSC Dull Department
January 2011 Rules for ice and cold operations. "Winterisation of vessels", http://www.skibstekniskselskab.dk/public/dokumenter/Skibsteknisk/Download%20materiale/2011/Arktisk%20Sejlads/Lloyds.pdf

[66] For a discussion of the geopolitics of the Northern Sea Route see Margaret Blunden, 'Geopolitics and the Northern Sea Route', International Affairs, 88/1, 2012, pp. 115-129.

[67] See rus-shipping.ru

[68] The following data are drawn from the Arctic Transport Accessibility Model (ATAM). See Scott R. Stephenson, Laurence C. Smith and John A. Agnew, 'Divergent long-term trajectories of human access to the Arctic', Nature Climate Change 1, 2011.

[69] Greenland in Fact 2011

[70] 'Management plans for the nature reserve on eastern Svalbard', Svalbard governor's office, November 2011.

[71] This is a brief, and simplified, summary. For an excellent description of some aspects of law in the Arctic see Michael Byers, Who Owns the Arctic?, 2010.

[72] See Klaus Dodds, 'The Governance of the Global Commons: Much Unfinished Business?', Global Policy, Vol. 3, Issue 1, 2012 and J. Ashley Roach, 'The Central Arctic Ocean: Another Global Commons' in the same issue of Global Policy.

[73] Michael Kavanagh and Sylvia Pfeifer, 'Centrica in £13 billion supply deal with Statoil', Financial Times, 21 November 2011.

[74] Oil Spill Prevention and Response in the U.S. Arctic Ocean: Unexamined Risks, Unacceptable Consequences, prepared by Nuka Research and Planning Group, LLC Pearson Consulting, LLC. Commissioned by: U.S. Arctic Program, Pew Environment Group. November 2010

[75] Reuters (February 2011) U.S. icebreakers can't handle Alaska oil spills: official, http://www.reuters.com/article/2011/02/11/us-arctic-oil-vessels-idUSTRE71A5RM20110211

[76] 'Gazprom ready to pay over $500 mln for sea-based helicopter platform at Shtokman', Interfax, February 21 2012.

[77] See, for example, Lloyd's, Drilling in Extreme Environments: Challenges and Implications for the Energy Insurance Industry, 2011.

[78] C. Chanjaroen and P. Dobson, 'Alaskan Pipeline Shutdown Cuts Oil Output, Raises Prices', Bloomberg, 10 January 2011.

[79] Anchorage Daily News (January 2011) Oil pipeline shutdown among longest ever http://www.adn.com/2011/01/10/1641685/alyeska-plans-bypass-to-restart.html

[80] See, for example, 'Statoil Shuts Snohvit Gas Field, Melkoya LNG Plant Due To Leak', Wall Street Journal, 13 January 2012.

[81] Platts (January 2011) Statoil says Snohvit LNG output to resume H2 Jan, http://www.platts.com/RSSFeedDetailedNews/RSSFeed/Oil/8362448

[82] See, for example, Amec Earth and Environmental, Grand Banks Iceberg Management, 2007 available at ftp2.chc.nrc.ca/.../GB_Iceberg_Manage_Overview_07.pdf

[83] See, for example, An Assessment of Emissions and Mitigation Options for Black Carbon for the Arctic Council, Arctic Council, May 2011.

[84] See Marla Cone, Silent Snow: The Slow Poisoning of the Arctic, 2006.

[85] These and other data are from Arctic Pollution 2011, Arctic Monitoring and Assessment Programme, 2011.

[86] See, for example, Leslie Holland-Bartels and Brenda Pierce, An Evaluation of the Science Needs to Inform Decisions on Outer Continental Shelf Energy Development in the Chukchi and Beaufort Seas, Alaska, United States Geological Survey, June 2011.

[87] See Lloyd's, Drilling in Extreme Environments: Challenges and Implications for the Energy Insurance Industry, 2011, pp. 20–25.

[88] See International Maritime Organization: www.imo.org/blast/mainframe.asp?topic_id=758&doc_id=3231

[89] The International Maritime Organization's Hazardous and Noxious Substances by Sea Protocol (HNS) adopted in 2010. See www.hnsconvention.org/Pages/TheConvention.aspx

[90] The EU's Environmental Liability Directive covers significant damage to habitats and species but applies only to inland waters in member states' economic zones and makes no provision for financial guarantees or compensation funds. See Sandy Luk, Rowan Ryrie, Legal background paper: Environmental Regulation of Oil Rigs in EU Waters and Potential Accidents, 2011, available at, www.clientearth.org/reports/marine-protection-clientearth-briefing-on-legal-implications-of-oil-rigs.pdf

[91] "Oil Spill Preparedness and Response; Liability and Compensation Issues", presentation by Maja Sofie Burgaard, Special Advisor Licence Department, Petroleum Section Bureau of Minerals and Petroleum Greenland Government at the Scoping session of Arctic Council Task Force on Oil Spill Preparedness and Response, Oslo, 17–18 October 2011.

[92] For more information about RODAC, see http://www.neb-one.gc.ca/clf-nsi/rthnb/pplctnsbfrthnb/rctcffshrdrllngrvw/fnlrprt2011/fnlrprt2011-eng.html#s6_1

93 Doug Matthew, 'The Prospects and the Perils of Beaufort Sea Oil: How Canada is Dealing with Its High North', IAGS Journal of Energy Security, 31 May 2011.

94 Oil Spill Prevention and Response in the U.S. Arctic Ocean: Unexamined Risks, Unacceptable Consequences. Prepared by Nuka Research and Planning Group, LLC on behalf of The Pew Environmental Trust, November 2010.

95 See, for example, Nathan Vanderklippe, 'Oil drillers willing to accept liability for accidents in Arctic', Globe and Mail, 13 September 2011.

96 For example, a critique of the current Canadian liability regime by Ecojustice Environmental Law Clinic in Ottowa claims that: "Such liability limits amount to a public subsidy of the offshore oil industry: by effectively committing public funds to cover any costs above the cap, oil companies are allowed to escape the prospective costs of a disaster and to anticipate the shifting of such costs onto the public." Amos & Daller, 2010, p. 3.

97 Tim Webb, 'Greenland wants $2bn bond from oil firms keen to drill in its Arctic waters', The Guardian, 12 November 2010.

98 Alaska Dispatch (December 2011) Russian icebreaker to deliver fuel to Nome, highlighting shortage of U.S. icebreakers, http://www.alaskadispatch.com/article/russian-icebreaker-deliver-fuel-nome-highlighting-shortage-us-icebreakers

99 Physorg.com (February 2012) Oil drilling in Arctic nears reality as Shell emergency plan is approved, http://www.physorg.com/news/2012-02-oil-drilling-arctic-nears-reality.html

100 Barents Observer (December 2012) Largest accident in Russian Oil sector, http://www.barentsobserver.com/largest-accident-in-russian-oil-sector.5001381-116320.html

101 Lloyd & Partners Limited, Energy and Marine Insurance Newsletter (January 2012) http://www.lloydandpartners.com/content/s4/publications/newsletters/EnergyMarineNewsletterJan12.pdf

102 Associated Press (December 2011) Drill in Arctic seas? Rig that sunk, killing 53, casts doubthttp://www.msnbc.msn.com/id/45777067/ns/world_news-world_environment/t/drill-arctic-seas-rig-sunk-killing-casts-doubt/

103 Shell "Technology in the Arctic" http://www-static.shell.com/static/innovation/downloads/arctic/technology_in_the_arctic.pdf

104 http://www.statoil.com/en/TechnologyInnovation/FieldDevelopment/AboutSubsea/Pages/Havbunnsanlegg.aspx

105 Bloomberg (December 2011) Arctic Drillers Must Have Same-Season Relief Well Ability, Regulator Says, http://www.bloomberg.com/news/2011-12-15/arctic-drillers-must-have-same-season-relief-well-ability-regulator-says.html

106 Arctic drillers face no shortage of underwater risks http://www.albertaoilmagazine.com/2012/01/arctic-drillers-face-no-shortage-of-underwater-risks/

107 Nunatsiaq Online (March 2011) Canada's Arctic: A hotspot for earthquakeshttp://www.nunatsiaqonline.ca/stories/article/1248_canadas_arctic_a_hotspot_for_earthquakes/

108 JH2012/004 Joint Hull Committee, Navigation Limits Sub-Committee, Northern Sea Routes

109 Arctic Council (2009) Arctic Marine Shipping Assessment http://www.arctic.gov/publications/AMSA/front_covers.pdf

110 ExxonMobil, The Valdez oil spill, http://www.exxonmobil.com/Corporate/about_issues_valdez.aspx

111 See, for example, 'Shell cedes control of Sakhalin-2 as Kremlin exerts its iron fist', The Independent, 12 December 2006, available at http://www.independent.co.uk/news/business/analysis-and-features/shell-cedes-control-of-sakhalin2-as-kremlin-exerts-its-iron-fist-428157.html

112 Article 234, UN Convention on the Law of the Sea (1982; 1994).

113 The JHC has also recently published a paper providing guidance and highlighting underwriting considerations for marine insurers. Although the paper relates to the Northern Sea Route, much of the guidance in the paper is relevant to all regions in the Arctic. Available at http://www.lmalloyds.com/Web/Market_Places/_nbsp__nbsp_Marine/Joint_Hull/Navigating_Limits/Web/market_places/marine/JHC_Nav_Limits/Navigating_Limits_Sub-Committee.aspx?hkey=2d77be10-50db-4b30-b43a-a2937ea83625

114 See, for example, Drilling in extreme environments: Challenges and implications for the energy insurance industry, Lloyds, 2011.

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