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Future of the Sea: Implications from Opening Arctic Sea Routes

Foresight – Future of the Sea
Evidence Review

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Future of the Sea: Implications from Opening Arctic Sea Routes

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Contents

Executive Summary

The Arctic is warming faster than anywhere else on Earth; satellite observations have revealed the region is losing sea ice at a dramatic rate and this decline is expected to continue. This loss of sea ice is creating opportunities for shorter global trade links between East Asia and the UK via the Arctic. The Northern Sea Route and Northwest Passages are seasonally open most years, although specialised vessels are currently required. The Arctic shipping season will continue to extend tripling in length by mid-century, coinciding with the opening of the Transpolar Sea Route across the central Arctic Ocean, although there will still be sea ice present in the Arctic winter. Typically by mid-century voyages from East Asia to the UK could save 10–12 days by using trans-Arctic routes instead of the Suez Canal route. These findings suggest that trans-Arctic routes may provide a useful supplement to the traditional canal routes, but they will likely not replace them.

There are mixed views on whether trans-Arctic routes will become economically viable. The Russian government wishes to develop the Northern Sea Route as a commercial enterprise and offers substantial fee-based services such as ice-breaking support and pilotage, which are certainly necessary for future investment and development of the route. However Arctic transport is also likely to grow due to increased destination shipping to serve natural resource extraction projects and cruise tourism.

The UK is well positioned, geographically, geopolitically, and commercially, to benefit from a symbiotic relationship with increasing Arctic shipping. The UK has a prominent role in Arctic science and a world-leading maritime services industry based in London, including the International Maritime Organization (IMO), one of the world's leading financial centres, and Europe's largest insurance sector. Arctic economic growth is focused in four key sectors – mineral resources, fisheries, logistics, and tourism – all of which require shipping, and could generate investment reaching $100bn (US Dollars and hereafter) or more in the Arctic region over the next decade. The UK had a fundamental role in preparing the UN IMO Polar Code which came into operation in January 2017. The Polar Code is an historic milestone in addressing the specific risks faced by Arctic shipping and acts to supplement the existing Safety of Life at Sea (SOLAS) and Marine Pollution (MARPOL) conventions for protecting the environment while ensuring safe shipping in international waters.

Much of the investment into Arctic shipping projects is from China but northern European countries are also playing an increasing role. Potential opportunities for the UK include the development of UK-based Arctic cruise tourism, and a UK-based trans-shipment port – transferring goods from ice-classed vessels to conventional carriers. The UK's active diplomatic role in many international organisations means it is well placed to ensure that increased activity in the Arctic is accomplished in line with established UN maritime conventions, many of which were written with significant UK contributions. The UK's leading role in Arctic science has wide reaching positive implications for international collaboration. To enhance predictions of the future Arctic, further developments in climate modelling and science are required.

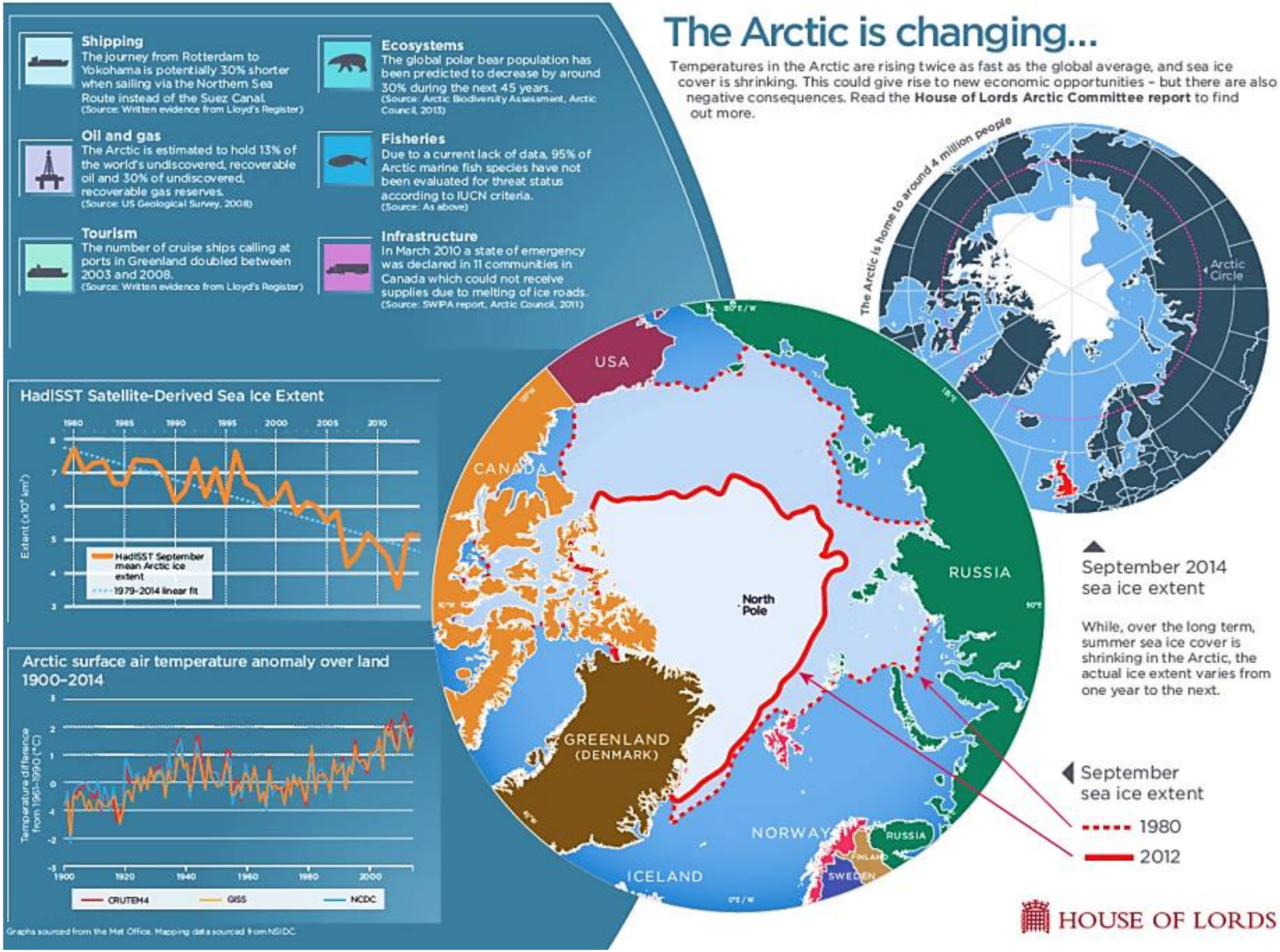

Figure 1. Infographic summarising House of Lords (2015) "Responding to a Changing Arctic".

Introduction

The UK's Arctic policy as set out in the Foreign & Commonwealth Office (2013) "Arctic Policy Framework", recognises the underpinning role of science in directly contributing to diplomacy, policy and our understanding of the Arctic. This review examines the future of shipping through the Arctic Ocean with implications for UK Arctic policy and beyond. The latest scientific and economic research is referenced, along with views from leading UK and international experts from a variety of disciplines.

Figure 2 illustrates the connectedness of northern European ports to the rest of the world with Europe to East Asian trade comprising almost one-third of the world's container traffic. The geographically shortest route between the Atlantic and Pacific oceans is through the Arctic; however sea ice provides a formidable deterrent for all but the hardiest ships. Over the last four decades satellites have observed a rapid melting of Arctic sea ice and climate models unanimously project that this decline will continue throughout the 21st century, giving rise to the possibility of commercial trans-Arctic shipping in the near future.

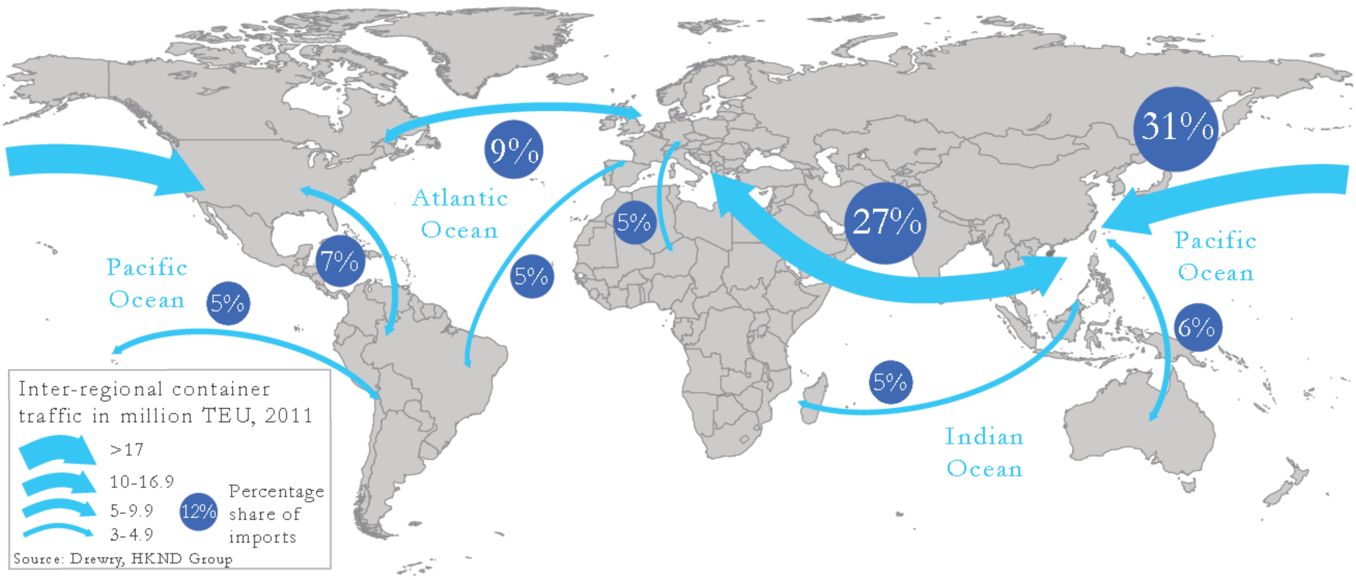

Figure 2. Inter-continental container shipping, 2011, taken from Humpert (2013).

This report presents the evidence for, and implications of, the opening of the Arctic sea routes, that are relevant to UK policy makers. The report addresses three related themes:

1. Evolution of Arctic Shipping Routes in the 21st Century

2. Commercial Viability of Arctic Routes

3. Potential Impacts of Open Arctic Routes on the UK's Maritime Interests

1. Evolution of Arctic Shipping Routes in the 21st Century

This section uses multiple climate-model simulations to assess Arctic changes for two future anthropogenic greenhouse gas emission scenarios: a low emission scenario in line with the UN ‘Paris’ climate deal aiming to keep global mean temperature rise below 2˚C, and a ‘business as usual’ (BaU) scenario where global greenhouse gas concentrations increase unabated. However, the future climate and hence Arctic shipping conditions may fall in between. These future scenarios and the range of simulated future changes to Arctic sea ice are summarised in Figure 3, adapted from the last Intergovernmental Panel on Climate Change (IPCC) report (Collins et al. 2013).

The Arctic is extremely sensitive to climate change and is responding faster than anywhere else on the planet. Since satellite observations of Arctic sea ice began in the late 1970s, the Arctic has, on average, lost 3000 km3/decade of sea ice. This rate is faster than the average depicted from climate-model simulations from the same period, fuelling debate about whether this higher loss rate will continue or is due to temporary climatic fluctuations.

All climate models include representations of the Arctic, with permafrost and ice sheets over land areas and a sea-ice component that floats on the ocean, moves with the winds and currents, and melts and re-freezes throughout the year. Regional climate, including in the Arctic, is always strongly coupled to global-scale changes and therefore, despite known weaknesses in current models that include coarse representations of Arctic islands and straits, these models are still the most reliable tools we have for making future projections.

Today the majority of journeys from East Asia to Europe sail via the Suez Canal while voyages to the US Atlantic Coast sail via the Panama Canal. However, voyages from East Asia to Europe through the Arctic are typically 40 per cent shorter in distance – potentially reducing journey times, saving fuel and costs. This is one reason why major shipping nations such as China, Japan, Singapore and South Korea sought and gained observer status to the Arctic Council[1,2] in May 2013, despite their lack of Arctic Circle territory. This section will use climate models to assess changes to the Arctic sea ice, the biggest physical barrier to Arctic shipping, to reveal the climatic potential for Arctic shipping; whether these new routes are likely to be used is discussed in Section 2.

[1] The Arctic Council consists of the eight Arctic States: Canada, the Kingdom of Denmark (including Greenland and the Faroe Islands), Finland, Iceland, Norway, Russia, Sweden and the United States.

[2] Thirteen non-Arctic States have been approved as Observers to the Arctic Council: France (2000), Germany (1998), Italian Republic (2013), Japan (2013), the Netherlands (1998), People’s Republic of China (2013), Poland (1998), Republic of India (2013), Republic of Korea (2013), Republic of Singapore (2013), Spain (2006), Switzerland (2017), United Kingdom (1998).

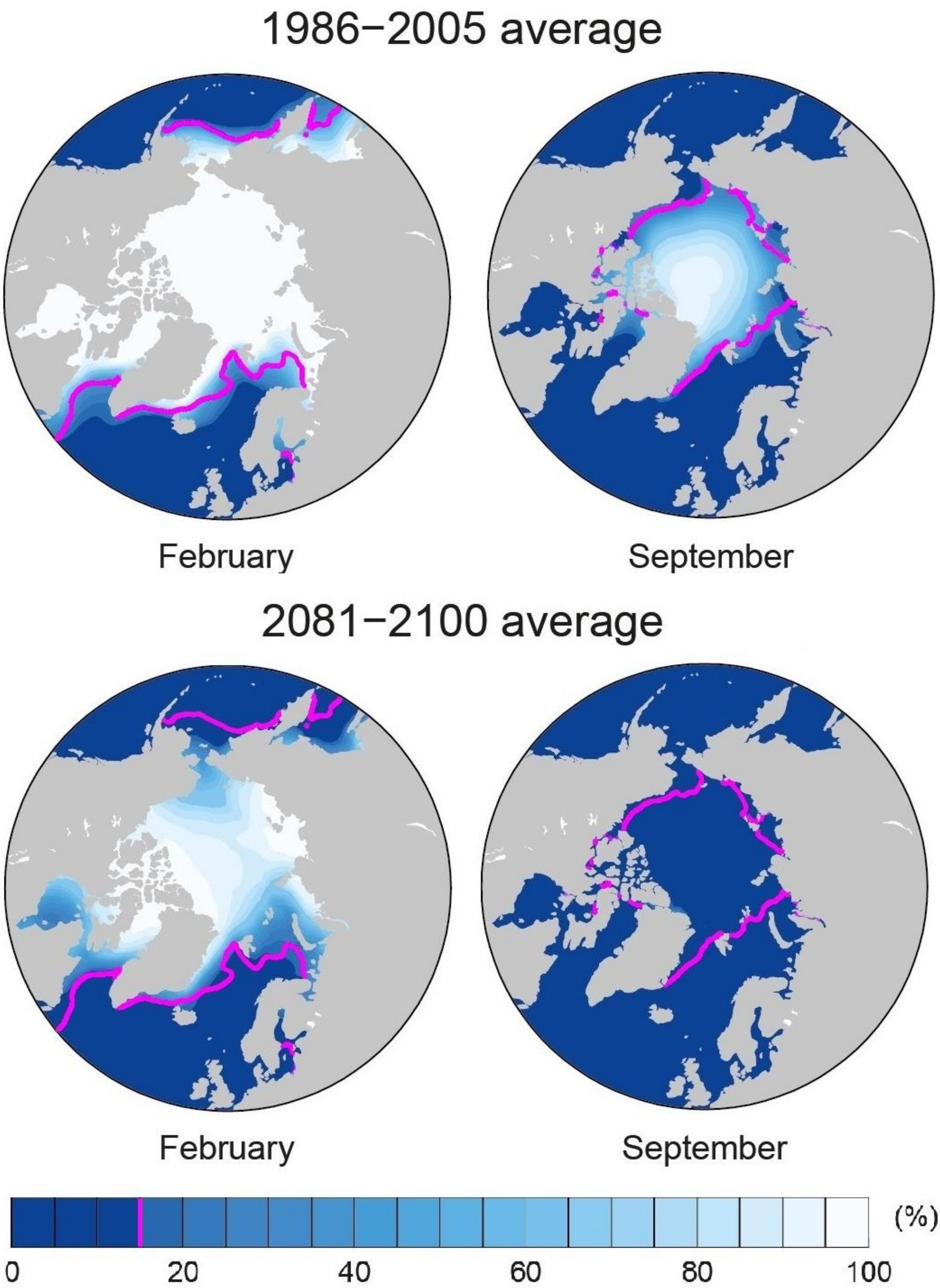

Figure 3. Changes in February and September multi-model mean Arctic sea-ice concentration from climate models for a 'business as usual' (BaU) emissions scenario. The pink contour represents satellite observed sea-ice extent 1986–2005 (15 per cent sea-ice concentration). Adapted from IPCC AR5 Figure 12.29 (Collins et al. 2013).

1.1 Recent Navigability on Arctic Routes

Trans-Arctic voyages are currently focused on two main routes (Figure 4): the Northern Sea Route[3] (NSR) – along Russia's northern coast – predominantly for journeys between Europe and Asia, and the Northwest Passage (NWP) through the Canadian Archipelago, as a route from the US East Coast to Asia. The fastest (direct) European route would be the Transpolar Sea Route (TSR) straight over the North Pole (Figure 4 grey route). Recent transit statistics for the NSR and NWP (Arctic Logistics Information Office 2015; Canadian Coast Guard 2015) are also shown in Figure 4; the statistics show an overall increase in trans-Arctic voyages. Shipping experts agree that these (few) voyages are exploratory in nature, 'testing the water' to see if Arctic routes are economically viable.

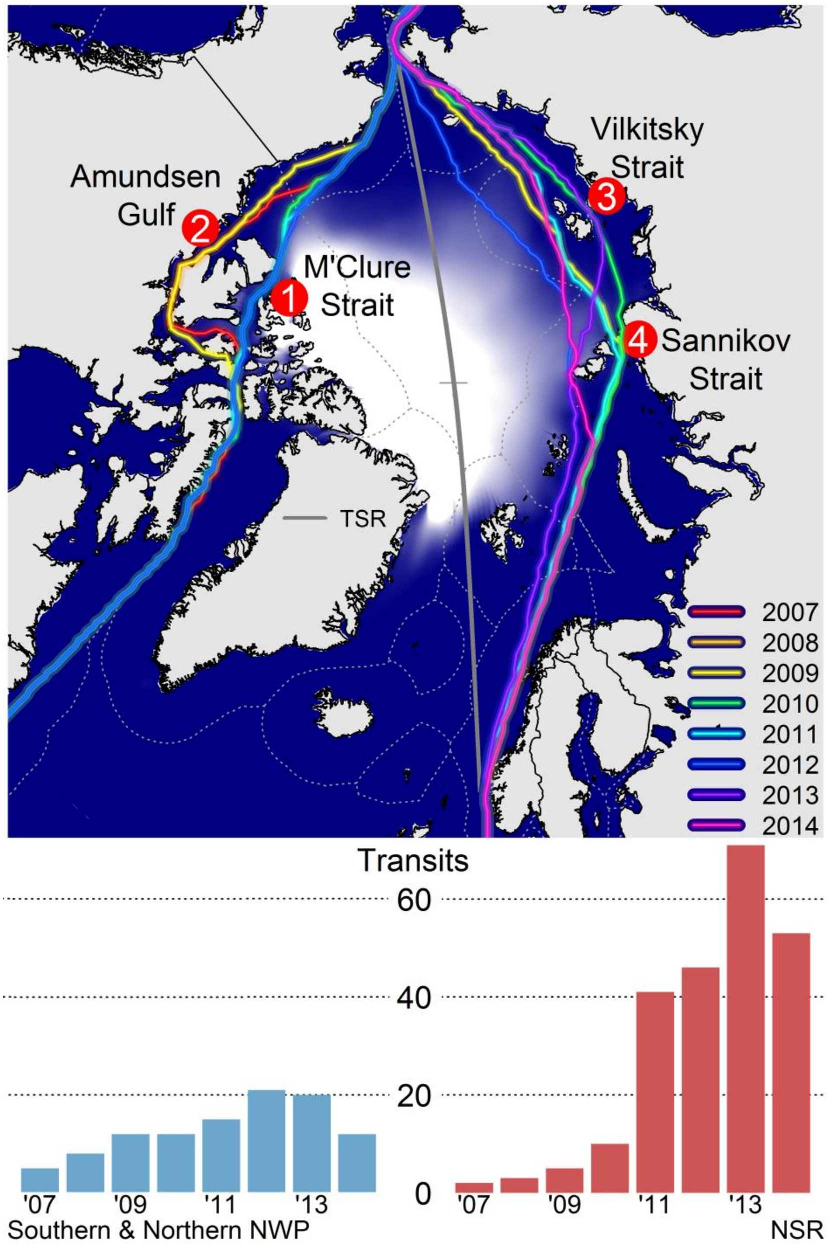

Figure 4. Fastest September trans-Arctic routes and recent transit statistics.

[3] The NSR is defined by Russian law to exist in the Arctic Ocean across the northern coasts of Russia/Siberia and is technically a subset of the Northeast Passage (NEP), although the two are often used synonymously.

1.2 Potential for Increase in Trans-Arctic Shipping

Simulations of future climate assume different anthropogenic scenarios for the concentrations of greenhouse gases (primarily CO_2) in the atmosphere. Here, results from a low CO_2 scenario that aims to keep global mean temperature rise below 2˚C, in line with the 'Paris' Climate agreements (Hulme 2016), and a high BaU CO_2 scenario are presented. Climate models unanimously project[4] that Arctic sea ice will continue in long-term decline beyond the middle of this century, regardless of the most optimistic mitigation strategies. However predicting when trans-Arctic routes will become available is complicated due to highly variable sea-ice distributions. For example, the very low sea-ice extent in 2007 did not exhibit open trans-Arctic routes due to a key strait remaining blocked with ice.

Results here are based on a recent study by Melia et al. (2016) using several different climate models, each constrained by recent sea-ice observations. This allows projections from multiple models to be more meaningfully combined to estimate uncertainty in future amounts of sea ice[5]. This builds on work by Smith and Stephenson (2013), Stephenson et al. (2013), and Barnhart et al. (2016). Figure 5 shows the fastest trans-Arctic sea routes, when available, to both open-water (OW) vessels (blue) and ice-strengthened Polar Class 6 (PC6) vessels (pink) during September (the most ice-free month), in all these future climate-model simulations.

Projections for the next couple of decades (Figure 5a, b) are similar for both scenarios, with relatively few tracks for OW vessels (30–40 per cent of Septembers available) and all confined to the NSR and NWP.[6] In contrast, ice-strengthened PC6 ships (capable in <1.2m thick ice) might find some variant of the TSR open during most (~90 per cent) Septembers. Using these routes OW and PC6 vessels would make a passage from North Sea ports to Yokohama in around 20 and 18 days respectively. Via Suez these journeys would take at least 30 days, not including any delays navigating the canal.

The mid-century routes (Figure 5c, d) are quite different for the Paris and BaU CO_2 scenarios. For the Paris scenario OW vessels can now sail trans-Arctic in 59 per cent of Septembers, still relying on variations of the NSR, although they can often avoid the Sannikov and Vilkitsky Straits (Figure 4) which have draft restrictions. For a BaU scenario OW vessels can cross in 82 per cent of Septembers with the TSR now often open, indicating that the central Arctic sea ice sometimes disappears entirely saving an additional 1–2 days' travel time. PC6 ships can always sail the fastest TSR routes (100 per cent).

[4] The word 'projection' is normally used for simulations of future climate to denote that the model predictions are contingent on the assumed pathway of greenhouse gas concentrations.

[5] Melia et al. (2015) shows that the calibration against current data markedly reduces the spread in climate-model projections but this does not necessarily guarantee improved future performance, e.g. Notz (2015).

[6] Even the latest generation of climate models used here struggle to depict the spatial details of islands and straits in the Canadian Archipelago. Although the calibration treatment of Melia et al. (2016) incorporates higher resolution data and helps with this, the ship routing projections for this region should still be treated with caution. Work by Aksenov et al. (2017) using one model with higher resolution show some near-future possibilities.

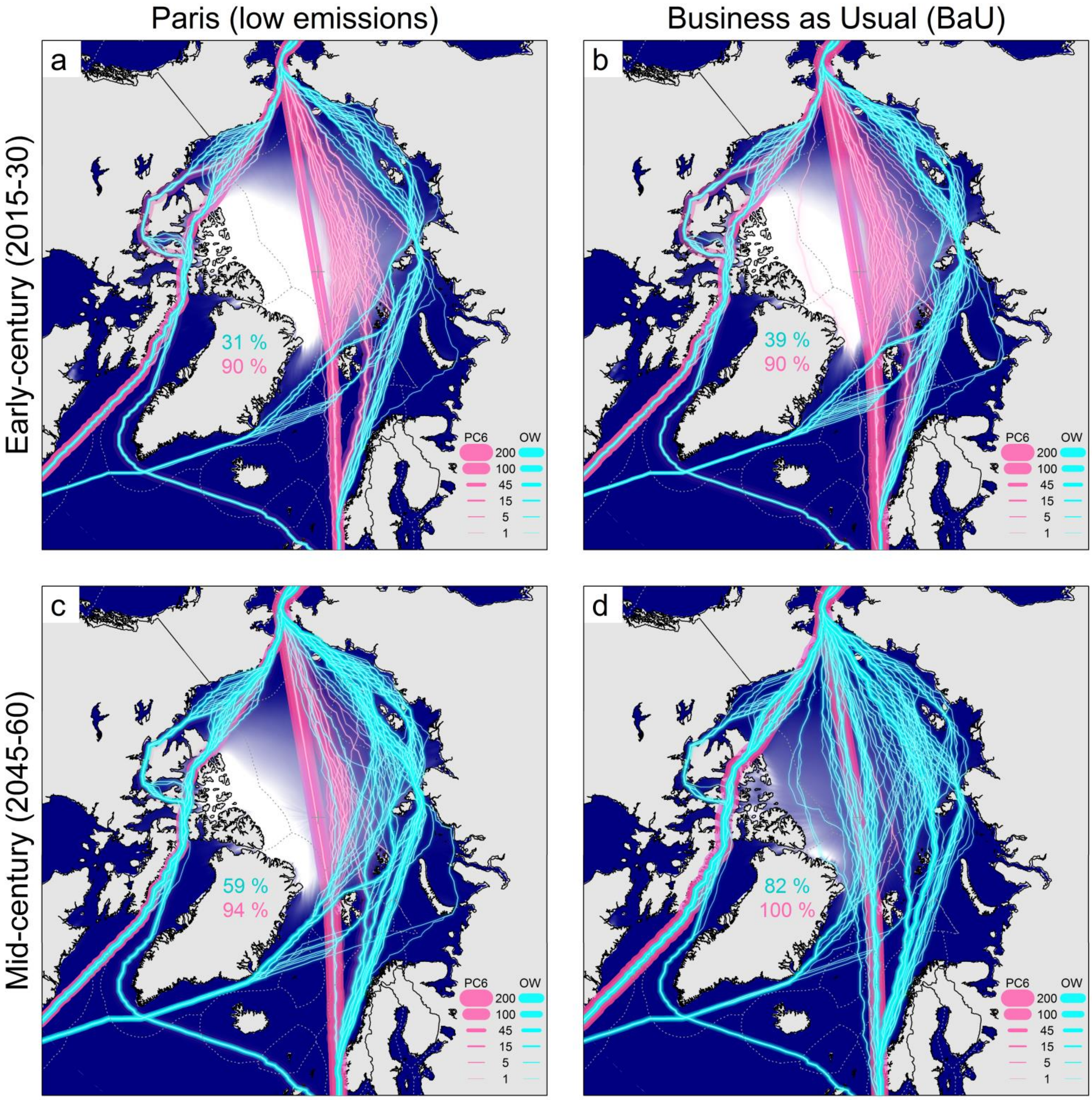

Figure 5. Fastest available September trans-Arctic routes from calibrated future climate simulations for Paris style scenario (a, c) and a BaU world (b, d). Cyan lines represent open-water (OW) vessels, and pink lines represent Polar Class 6 vessels (PC6, capable of navigating in sea ice 1.2 m thick); line weights indicate the number of transits using the same route, and percentages are the probability that Arctic routes are open for the respective vessel class.

1.3 Season Length Changes

Transit conditions always remain optimal around September, but future commercial shipping would likely require a much longer shipping season. Figure 6 shows the probability that any trans-arctic route would be available to OW vessels through different months, based on our multiple climate-model results. The widening of the shaded regions indicates that the shipping season will extend, becoming approximately a month longer every decade. By mid-century for a Paris scenario the number of navigable days per season is on average 2.5 times greater than early-century; for a BaU scenario this is 3.5 times greater. The BaU scenario therefore has 40 per cent more navigable days than Paris by mid-century. By late-century the majority of the Arctic Ocean is expected to be open water for half the year in a BaU world (also e.g. Barnhart et al. (2016); Laliberté et al. (2016)); however, during the transition, high-ice years will still occur (e.g. Notz 2015; Swart et al. 2015). Although year-round transits should be possible with ice-strengthened ships, the models suggest that OW transits will remain seasonal.

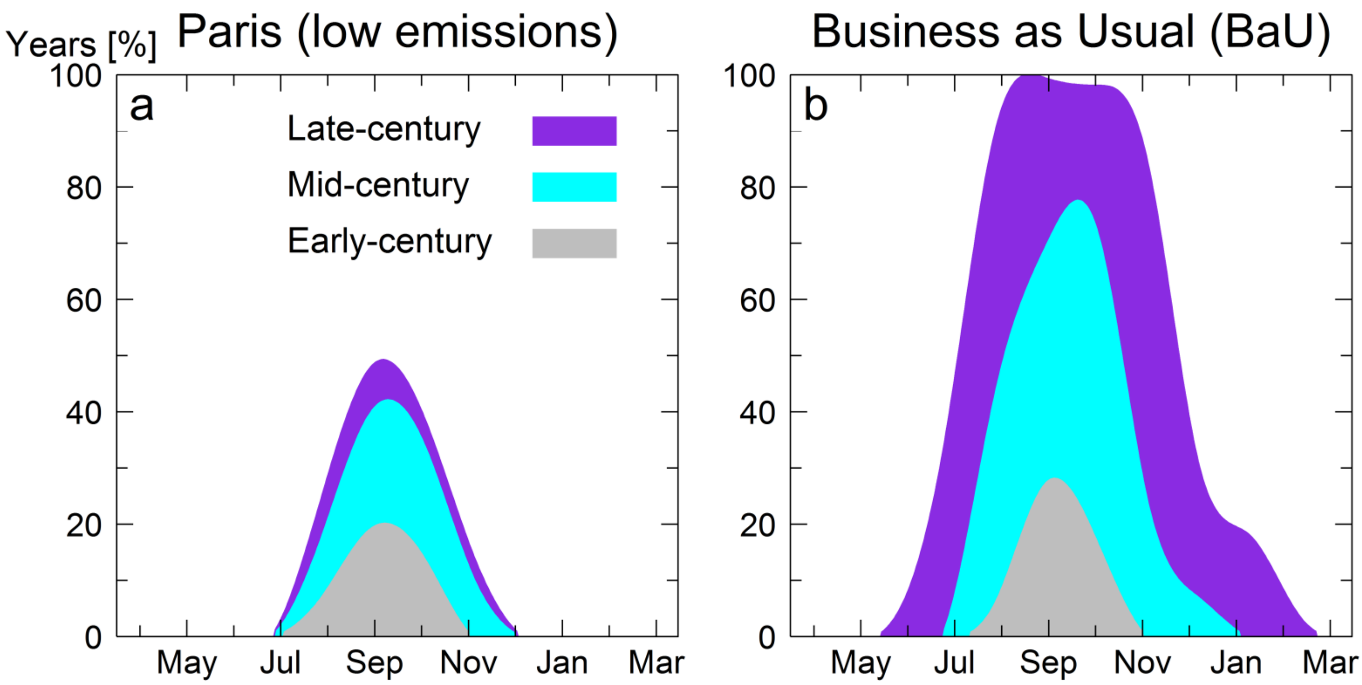

Figure 6. Probability of open trans-Arctic routes through the year for low and high future greenhouse gas scenarios. Early-century (2015–2030); mid-century (2045–2060); late-century (2075–2090).

2. Commercial Viability of Arctic Routes

Shipping in the Arctic can be broken down into two categories: ‘trans-Arctic’ shipping, as a short cut between the Pacific and Atlantic Oceans, and ‘destination’ shipping, to and from destinations within the Arctic. Although trans-Arctic shipping has increased since 2007 (Figure 4), the peak in destination shipping occurred under the Soviet Union, before the effects of climate change drastically affected the Arctic sea-ice pack on the scale seen in the last 20 years. This Soviet peak in shipping was supported with huge investments in icebreakers, ports, and infrastructure along the eastern Arctic coast.

2.1 Incentives & Challenges

Trans-Arctic routes are shorter and may lead to savings in travel time and fuel, and hence potential economic savings; however it currently requires specialist knowledge and flexibility not suited to some markets, for example container shipping which operates on strict schedules and a network of cargo exchange at ports en route. This is opposed to bulk shipping (carrying unpackaged cargo such as grains, oil, liquefied natural gas (LNG), ore, etc. in cargo holds) which generally operate on more flexible schedules.

Incentives for destination shipping include the development of natural resources spurred by global commodity prices, resupply to remote Arctic communities, fishing, research voyages and marine tourism. While climate change will increasingly open up Arctic shipping routes, the opposite is true for Arctic land surface transport. Here accessibility is likely to decrease due to warmer winters resulting in lost potential for winter road construction, melting permafrost, and deeper snow accumulations (Stephenson et al. 2011), perhaps leading to increased reliance on maritime transport links.

The major impediment to Arctic shipping is operating in the freezing and remote Arctic environment, which requires experienced Arctic crews, with specialist equipment and vessels. The world’s leading mutual insurer – UK P&I Club considers these additional risks and underwrites accordingly. The additional risks outlined by UK P&I Club (2014) are as follows.

1. Physical risks to the ship and crew from extreme weather, cold and ice conditions. Contact with ice floes and icebergs, ice accretion, restricted visibility and operational malfunctions due to cold. All can potentially contribute to cause delays and damage to the ship, her crew and cargo.

2. Lack of infrastructure compounding these physical risks, including poor communications, incomplete charting in some areas, unreliable navigational aids, and potential remoteness from all sources of help when an incident happens, including remoteness from salvage and clean-up facilities, search and rescue (SAR), medical assistance, surveyors and bunkering facilities.

3. Enhanced human element risks if the officers and crew lack the training and experience to address the difficulties noted above.

Autonomous systems are likely to become increasingly important to the maritime industry in combatting these risks; the majority (~80 per cent) of accidents are attributed to human errors (DNV GL 2015).

2.2 Economic Viability of Commercial Trans-Arctic Shipping

Studies into the economic feasibility of 21st century trans-Arctic shipping date back as early as Wergeland (1992), a year after the NSR became open to international traffic and just after the collapse of the Soviet Union. Lasserre (2014) compiled a comprehensive review of 26 such studies and finds that 13 conclude that Arctic routes can be profitable for commercial shipping, six are ambivalent or do not take a position, and seven conclude that conditions are currently too difficult to be profitable. This conflict in the literature continues for future economic projections, for example Bensassi et al. (2016) predict increases in trans-Arctic shipping during the 21st century to be minimal, while Bekkers et al. (2016) predict a shift of shipping traffic from Suez to Arctic routes.

The Russian NSR administration's advertised tariffs for transit along the NSR (Northern Sea Route Administration 2013), would make any routine use prohibitively expensive. However, Lasserre (2014) notes that the Finnish shipping company Tschudi finds that these rates are negotiable so as to attract future business. The NSR administration details a list of requirements and charges to operate on the NSR (Arctic Logistics Information Office 2015). To transit the NSR, a ship operator must apply for a permit between 15 and 120 days in advance of the estimated arrival in the NSR water area whereas the NWP currently has no fee system and the Canadian government will most likely not introduce fees, as it would discourage the economic viability of the route. However, insurance premiums vary widely; they are currently higher for the NWP than the NSR. The NSR is currently the most attractive of the three major route choices because of the favourable ice conditions, and Russia plays a powerful role in controlling the waters of the NSR. With future reductions in Arctic sea ice, the TSR via the central Arctic Ocean may become a more attractive prospect.

Lasserre (2014) concludes that ultimately the profitability of transits depends on destination, with Northeast Asian ports like Yokohama (Japan) being more profitable than more southerly Asian ports like Shanghai (China) due to the smaller distance savings. Transit time is noted as the most important factor determining profitability, rather than fuel cost, as faster journeys allow a higher frequency of voyages.

2.3 Commercial Traffic Types & Destinations

The vast majority of current shipping in Arctic waters is local or destination shipping. Ships automatically send their navigational information to tracking satellites and these data were used by Eguíluz et al. (2016) to find a total of 11,066 ships in Arctic waters in 2014 – 9.3 per cent of the world's shipping traffic. Of these ships 50 and 80 per cent of the traffic along the NSR and NWP were in the 'specialist' category (e.g. supply, research, and survey vessels), followed by fishing (1,960), cargo (1,892), tanker (524) and passenger vessels (308) (Figure 7). The vast majority (2,000 vessels per month) were in the North Atlantic (Barents Sea) region, the closest Arctic sea area to UK waters and where sea ice is least common.

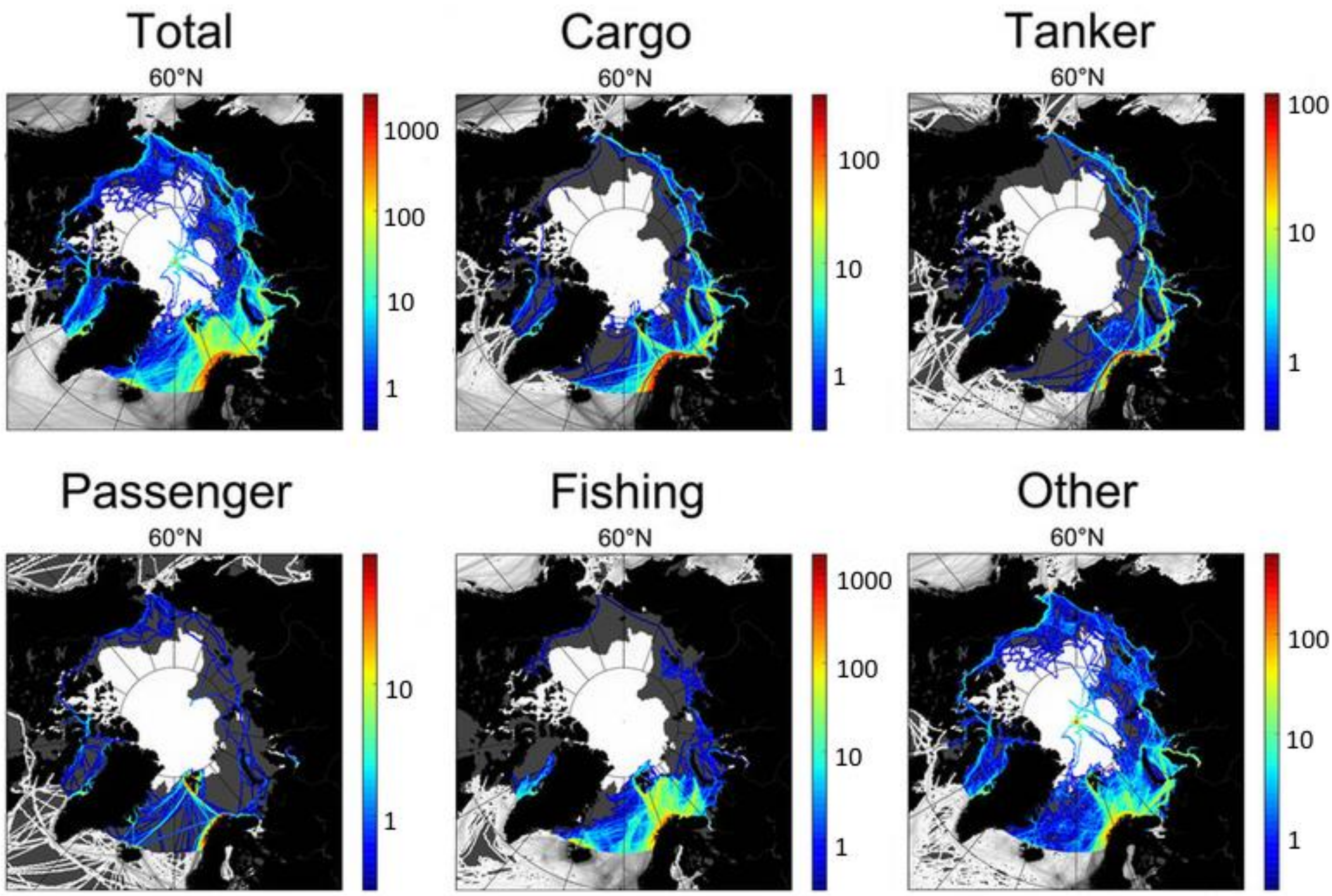

Figure 7. Monthly average number of ships per 1000 km^2 adapted from Eguíluz et al. (2016).

The three shipping sectors most likely to increase in Arctic waters are: (i) destination shipping which is likely to grow in line with increased natural resource extraction in the region (AMSA 2009) (also see Section 3.5.2); (ii) regular trans-Arctic shipping, which will require a reliable extension to the Arctic shipping season due to ice melt, along with the required commercial drivers (Section 2.5); (iii) 'cruise tourism', a sector where the UK could become a direct provider (Lloyd's Register 2015), and recent voyages like that of the Crystal Serenity in 2016 (Laursen 2016; Snider 2016) indicate that the commercial demand and technical knowledge is available (Section 2.4).

2.4 Route-Dependent Opportunities

The physical opportunities presented in Section 1 suggest that conditions along the NSR will be most favourable, with similar conditions on the NWP and the TSR around 10 and 30 years later respectively.

In the near term the NSR is the most popular route due to location, favourable ice conditions, and ice-breaker support from the Russian NSR administration. From mid-century availability of the faster TSR would avoid the Russian Exclusive Economic Zone (EEZ) and thus fees (see Table 1). Ice breaker tariffs may change when ice-free conditions on the NSR prevail for longer and if the TSR does become more viable, because Russia wishes to encourage regular use of the NSR (Soroka 2017).

Table 1. Current Arctic shipping activities within the Arctic Council coastal states' EEZ[a]. Adapted from Lloyd's Register (2015).

Shipping Type		Within EEZ[a] of Arctic Council coastal state				
		Canada	Greenland	Russia	US	Norway / Iceland
Destination Shipping	Passenger Cruise Ships	✔	✔		✔	
	Export of Natural resources	✔		✔		
	Local resupply	✔	✔	✔	✔	✔
	Fishing	✔	✔	✔	✔	✔
	Patrol / SAR	✔	✔	✔	✔	✔
Transit Shipping	Northern Sea Route (NSR)			✔		✔
	Northwest Passage (NWP)	✔			✔	✔
	Transpolar Sea Route (TSR)[b]	✔	✔	✔	✔	✔

[a] EEZ (Exclusive Economic Zone – typically 200 nautical miles from the shoreline) dependant on United Nations Convention on the Law of the Sea (UNCLOS) and extended continental shelf claims.
[b] Not currently used, the actual route of the trans-Arctic crossing may pass through Canada, Greenland, Russia, US, Norway and/or Iceland waters or international waters.

On the NWP, Canada currently offers no chartered ice-breaking support but they provide guidance, ice and meteorological forecasts, and SAR coverage. Although the route here is more technically challenging the remoteness and pristineness of the Canadian Archipelago and Greenland make the area attractive to cruise tourism as seen by the recent cruise by the Crystal Serenity (Laursen 2016; Snider 2016); which involved meticulous planning and consultancy with experts to manage the considerable risk potential.

2.5 Required Commercial Changes

For trans-Arctic shipping to be commercially viable and accommodate the higher volumes seen on established shipping routes, would require most of the following: additional en route ports and infrastructure, ice-breaking services, Polar Class vessels with experienced crew, SAR coverage/agreements, a globally high bunker fuel price, continued growth in Arctic exports, and availability of insurance underwriting. The recently ratified UN International Maritime Organization Polar Code (International Maritime Organization 2015), which outlines the safety requirements unique to sailing in Arctic waters, is also a necessary first step (Section 3.4).

For some cargo, the dominant economic factor is the price of bunker fuel. In 2016 the price dropped so far that some shipping operators shunned the Suez Canal route (and the associated transit costs) and voyaged via the Cape of Good Hope. The price of bunker fuel would need to increase so that the fuel savings from Arctic routes became more significant. Because of the continued presence of winter ice throughout the 21st century, shipping companies would have to adjust to a dual route model, using Arctic routes when possible and traditional routes when not. Alternatively, investments in ice class cargo ships like the PC6 and new technologies like dual acting ships and ship-launched navigation drones would potentially enable safe year-round trans-Arctic shipping. A renewing of the icebreaker fleet to maintain the routes and ports would also be required in the short to medium term when higher ice years remain more frequent.

In addition to the above, the Arctic would need investment for the development of infrastructure projects and logistical hubs as most of the region is underserved by transportation, port and other critical infrastructure. Increasing the Arctic's appeal for investment, for both public and private actors, could be pursued in many ways such as having stable and transparent political governance and judicial systems, along with a consistent and clearly defined regulatory regime. Large industrial projects are likely to be international, involving several Arctic States and even consumer countries. A framework to streamline such international collaboration would greatly facilitate investment (World Economic Forum 2014).

3. Potential Impacts of Open Arctic Routes on the UK's Maritime Interests

The public perception of the Arctic is of extensive ice, unique species and cultures, and untouched pristine landscapes. While largely true, the Arctic is also home to some 4 million people and an annual economy of roughly $230bn (World Economic Forum 2014).

Arctic economic growth is focused in four key sectors – mineral resources, fisheries, logistics and Arctic tourism – all of which require shipping, and could generate investment reaching $100bn or more in the Arctic region over the next decade. The UK already has a leading role in Arctic science, and London has the world's 20 largest active insurance and reinsurance companies (Foreign & Commonwealth Office 2013).

3.1 Economic Interests

Studies of the economic viability of Arctic shipping produce widely varying conclusions, and as far as the authors are aware there is no quantitative economic impact analysis regarding increased Arctic shipping specific to the UK's interests. More general observations on the UK's economic relationship with other Arctic States can be made however.

The UK enjoys healthy trading links with the Arctic Council Member States. Four of the eight member states – the United States, Russia, Canada and Sweden are also top 20 trading partners for the UK. Exports to Sweden were worth £5.6bn in 2013; in the same year, exports to Russia were worth £5.2bn and exports to Canada were worth £4.5bn (HMRC 2015). Bilateral trade between the UK and Norway is worth £18bn per annum, and Norway supplies 30 per cent of the UK's total energy (Prime Minister's Office 2012), and 55 per cent of UK gas imports (Foreign & Commonwealth Office 2013). UK exports to Finland totalled £1.75bn in 2013, and the UK is the largest supplier of imported services and the 10th largest total supplier of imported goods to Iceland (Kochis 2015).

In 2015, UK shipbuilder Cammell Laird was awarded the contract to build the new Arctic research ship RRS Sir David Attenborough amid international competition. This single £200m project simultaneously secured 400 jobs, and the future of the UK as a world leader in polar research (BBC 2015). Cammell Laird is committed to investing in British companies like Rolls Royce for the build, which is the biggest commercial shipbuilding contract in Britain and restores British shipbuilding capability for icy waters.

3.2 International Comparisons

3.2.1 The UK

The UK, and London in particular, is a world leader for maritime services, many of which need Arctic-specific knowledge. The IMO is based in London and the UK also has Arctic operations experience with the British Antarctic Survey and the Royal Navy, and within industry like BP. The UK is able to offer businesses a ‘one-stop shop’ for maritime services because the City of London is home to a wealth of companies providing expertise across all sectors (Department for Transport 2017). In insurance, the UK leads the world, with a 35 per cent share of global marine insurance premiums, and 60 per cent of protection and indemnity insurance. In broking, 26 per cent of global shipbroking is undertaken in the UK, significantly more than any of its rivals and the UK has more than half the global share of tanker charter business and up to 40 per cent of dry-bulk charters. English law is the global industry standard and the UK boasts unrivalled legal and judicial expertise on shipping, insurance and international trade matters with 25 per cent of maritime legal partners practising in the UK. London is home to the leading source of market information on the trading and settlement of physical and financial shipping derivatives in the Baltic Exchange, with the majority of the Exchange’s members based in London. The UK maritime sector directly contributes around £13.5bn to GDP and supports over 110,000 jobs.

The UK ports industry is the largest in Europe and the scale of diversity of operations includes all-purpose facilities, as well as container, bulk, ferry and cruise terminals. Approximately 96 per cent of the volume of all UK import/export trade enters the UK through its ports. In addition, some 32 million international passengers use UK ports every year while another 38 million use them for domestic journeys. The UK is the second to the US (18.1 per cent) in worldwide earnings from services and income as a proportion of world exports with 7.4 per cent, compared with 19.2 per cent for Europe, 7 per cent Germany and 5.3 per cent France (UKTI 2013). The House of Lords (2015) points to Aberdeen’s role as a centre of expertise for the oil and gas industry and adds that northern and eastern UK ports might be well placed to take advantage of the expansion of the NSR and eventually TSR traffic; the role, strategic location and expertise in Scotland should therefore be highlighted in future policy (Bailes and MacDonald 2015). Scotland’s first minister Nicola Sturgeon highlighted her vision of Scotland as an Arctic Nation at the 2016 Arctic Circle conference (Bennett 2016).

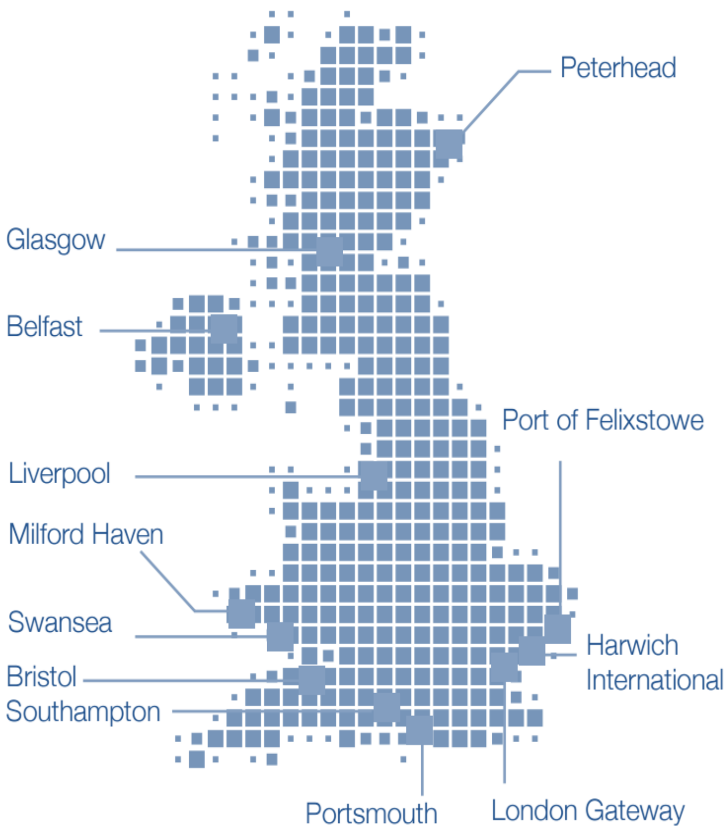

Figure 8. Location of the UK’s major ports, adapted from UKTI (2013).

3.2.2 The Rest of the World

Currently the main providers of Arctic shipping are entities that reside within the Arctic with Russia (e.g. Sovcomflot), Canada (e.g. Fednav) and the Scandinavian countries the biggest players. The Canadian and US ice-breaking fleets are less than one-sixth the size of the Russian fleet (Appendix 1). In 2015, the Russian government released their ‘Integrated Development Plan for the Northern Sea Route 2015–2030’. The plan stresses the importance of providing safer and more reliable navigation on the NSR for maritime export of Russian natural resources and the strategic importance of NSR for Russian national security. The plan is also to increase international transit cargo transportation along the NSR in partnership with Asian countries and in particular with China (Gunnarsson 2016).

Arctic shipping technology providers typically supply services globally; currently there are only a very small number of these specialist technology providers, most notably in Finland. Total, the French multinational oil and gas company, is involved in the huge LNG project on the Yamal Peninsula involving 15 ice-breaking tankers built in South Korea and a $15bn investment from China. The European-Union-flagged fleet accounts for about 20 per cent of the world’s shipping fleet; maritime freight transport is projected to grow at high rates in Europe; a report sponsored by the European Commission projects an inter-continental tonne-kilometre growth for the EU of 71 per cent from 2020–2050 (Petersen et al. 2009).

In 2009, a German company made the first non-Russian commercial transit voyage on the NSR, from South Korea to Rotterdam, shaving 3,000 nautical miles off the Suez Canal route, and making estimated savings of $300,000 for each of the two vessels involved (Blunden 2012). In 2009, 22 per cent of German exports were destined for China, compared with just 9 per cent in 2002 (Pålsson and Bengtsson 2008). German transport vessels supply western Siberia, and German shipyards are building more ships than ever before that are capable of navigating the northern routes (Blunden 2012).

East Asia has a substantial impact on global trade, and shipping underpins the Asian economic system. Both Japan and South Korea have a keen interest in the commercialisation of the NSR, but it is China that has most at stake. As the NSR becomes increasingly vital to supply China’s demand for raw materials from the Arctic, the Chinese are increasingly collaborating with the Russia and its state owned shipping company Sovcomflot. However this investment by China is not unique to the Arctic, China is investing heavily in port infrastructure in other regions too, and China’s international trade with Northern Europe is one of many inter-continental interests (Humpert 2013).

3.3 Geopolitical Considerations

The Arctic relies on collaboration across borders and in this respect is a model of how diplomacy can work in an area of mutual interest. Activities on the sea floor are largely scientific in nature and claims of extensions to continental boundaries are dealt with through conventional UN channels as elsewhere in the world (World Economic Forum 2014).

Increasing traffic sailing from the Arctic into the UK’s northern area of interest will raise questions about maritime domain awareness, and SAR in the waters north of the British Isles. Currently the UK Coastguard has responsibility in waters adjacent to the Arctic which could be affected by increased traffic. The Arctic States are cooperating closely on SAR but they lack resources. Noting these deficiencies, the House of Lords (2015) argue that the UK should shoulder its responsibility in this area and "give urgent attention to developing a pan-Arctic SAR strategy along with the Arctic States". The government responded that it "will monitor developments and assist as appropriate in the further development of plans for search and rescue in the Arctic" but that it was clear that "responsibility for search and rescue in Arctic waters rests squarely with the Arctic States" and that these States "should lead on the development of any comprehensive strategy towards search and rescue in the Arctic".

The re-commissioning of Arctic Cold War bases (Figure 9) is providing Russia with a huge geostrategic advantage in that it can move its naval fleet to Asia far faster, and giving flexibility that Russian military planners rarely had before (Coffey 2015). This military infrastructure build-up has raised some concerns in other Arctic States given the wider geopolitical context, but is not generally viewed as a threat as Russia's focus seems to be predominantly on regional security and in protecting its sea routes (Wilton Park 2016).

The industrial developments along the Yamal Peninsula (Figure 9, location 15) combined with re-commissioning Arctic military bases led to a 40 per cent year-on-year increase in activity for Arctic ports in 2016 (Staalesen 2017) and could in future provide vital SAR cover and emergency portage required to expand the NSR.

As a non-Arctic State, the UK has no territorial jurisdiction in the Arctic, but it does have influence through actively engaging with the Arctic Council as a State Observer. Use of the UK's polar logistics, including the new polar research vessel, will be prioritised in Antarctica, although the Research Council's Arctic Office and Arctic Research Programme plans to continue to support the wide range of UK scientific interests in the Arctic region (Depledge 2014).

Although Arctic routes have their challenges, the traditional trade routes have threats too (Table 2). The various chokepoints have limits for ship size and weight. Some of the regions passed through present security hazards with threats of terrorism and piracy. The 1956 Suez Crisis showed how quickly passage through the region could be halted by political instability; a

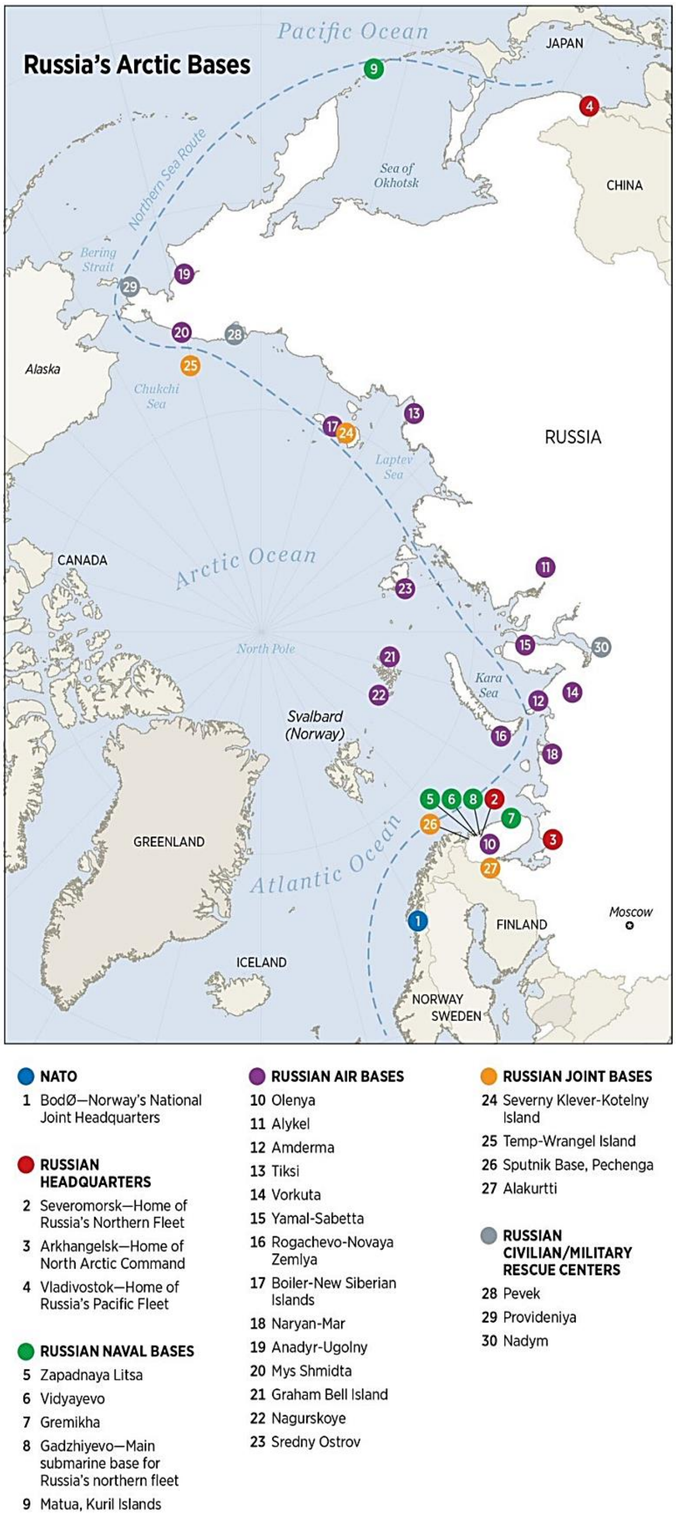

Figure 9. Russia's Arctic Bases (Wood 2016).

repeat of these or similar events in the 21st century would force shipping to use longer routes via the Cape of Good Hope and Panama Canal; if conditions permit, the far shorter trans-Arctic routes could provide an attractive option (Table 2).

Table 2. Global Chokepoints

Chokepoint	Location	Vessels per year	Capacity (DWT*)	Threat
Strait of Hormuz	Separates Iran from the Arabian Peninsula	50,000	Narrow	Regional Instability & Terrorism
Suez Canal	Egypt, connects the Mediterranean and the Red seas	17,228	200k DWT, convoy limit	Terrorism
Bosphorus	Istanbul, Turkey, between the Mediterranean and Black Seas	50,000	Ship size, 200k DWT	Controls
Strait of Malacca	Separates Malaysia from Indonesia, connects the Pacific to the Indian Oceans	60,000	300k DWT	Terrorism & Piracy
Panama Canal	Panama, connects the Atlantic and Pacific Oceans	14,323	120k DWT	N/A
Strait Bab el-Mandeb	Separates the Arabian Peninsula from the Horn of Africa, connects the Red Sea to the Gulf of Aden	22,000	Narrow	Terrorism & Piracy

*Dead weight tonnage

3.4 Safety & Sustainability of Arctic Operations

Increased shipping in the Arctic presents increased risks and will undoubtedly have indigenous social and environmental repercussions (IMarEST 2016). Impacts on the sensitive Arctic environment include: emissions of black carbon,[7] risk of introducing invasive species, and chemical contamination. All of these could outweigh the economic benefits of increased Arctic shipping, but could also potentially be mitigated by appropriate legislation. Risks to personnel include inadequate SAR capability and dangers of operating in extreme conditions, although risks can be reduced with adequate training. Many of the mandatory legislations and voluntary guidelines are developed and supported with the aid of UK organisations. The UN IMO Polar Code, which came into operation 1 January 2017, is a key advance in guidelines for Arctic shipping and acts to supplement the SOLAS and MARPOL conventions which have been effective in protecting the environment while ensuring safe shipping in international waters. Led by Lloyd's of London in conjunction with the Nordic Association of Marine Insurers, the International Union Marine Insurance and Lloyd's Register, and with the close cooperation of the Arctic and Antarctic States, this has helped establish a single ice navigation regime system,

[7] Formed through the incomplete combustion of fossil fuels, black carbon acts to warm the climate by absorbing solar energy; Arctic shipping is a source of black carbon, where deposition over snow and ice can lead to increased melting.

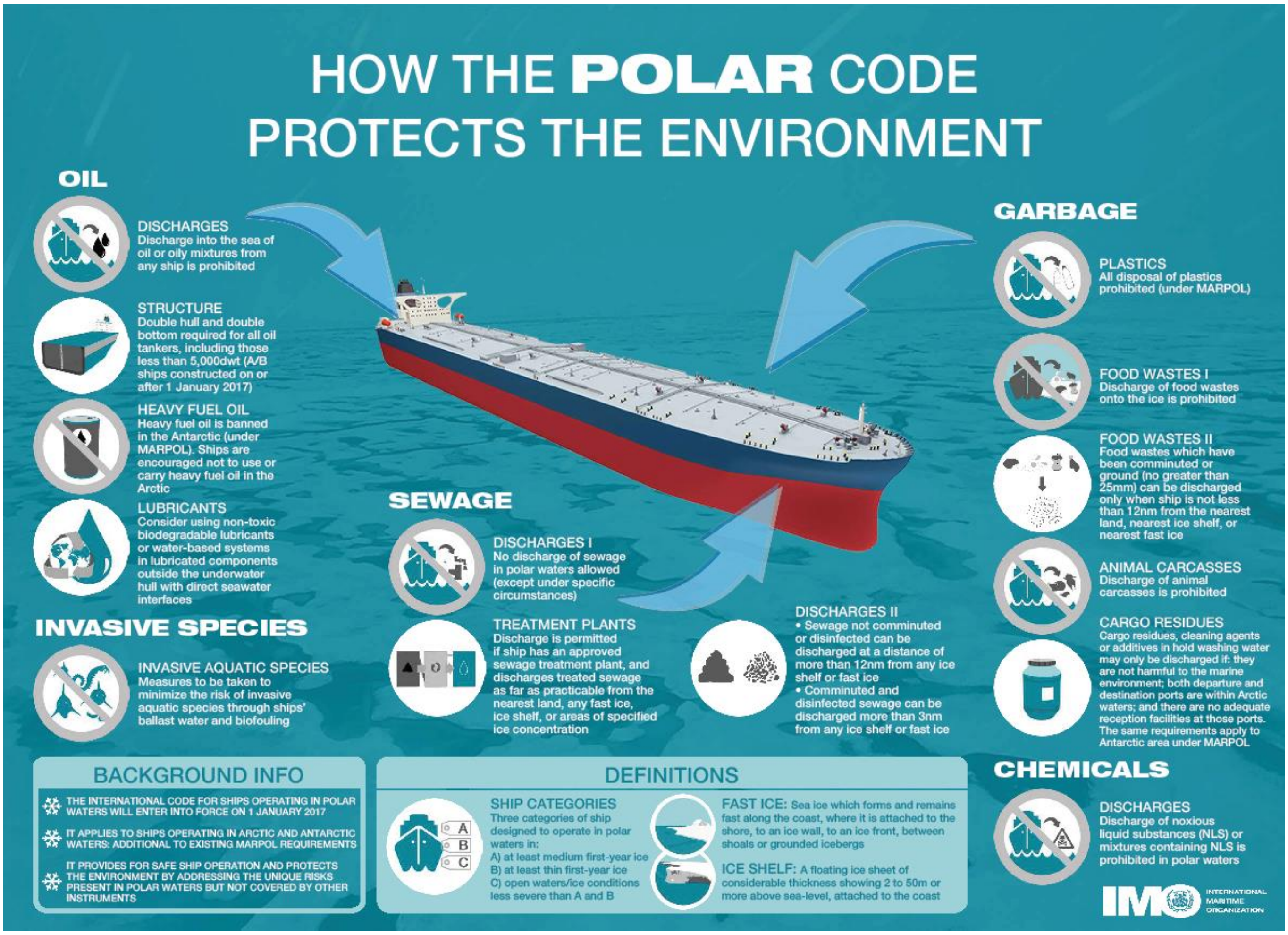

Figure 10. An illustrative guide of the Polar Code to the protection of the environment designed by the IMO to raise awareness (Source: IMO[8]).

to give guidance for a range of planned and possible situations that might emerge when operating a ship in polar waters. Oil discharge in the Arctic remains a big issue, and while major operators follow best practice it is possible that rogue operators could bring the whole industry into disrepute (IMarEST 2016). The IMO Polar Code advances environmental protection for Arctic waters by banning all discharge of waste; however some environmental groups have been critical of the Polar Code for 'not going far enough'. There remain governance challenges in the implementation, awareness, enforcement and coordination of these and other issues, suggesting that further legislation may be needed – the UK could assist with this.

London-based maritime organisations have led the development of significant international regulation for the protection of seafarers, the environment and the indigenous peoples of the Polar Regions. The Polar Code is a demonstration of the maritime strength of the City of London and is an example of what industry, governments and international regulators can achieve by working together (M. Kingston 2016, personal communication, December 2016).

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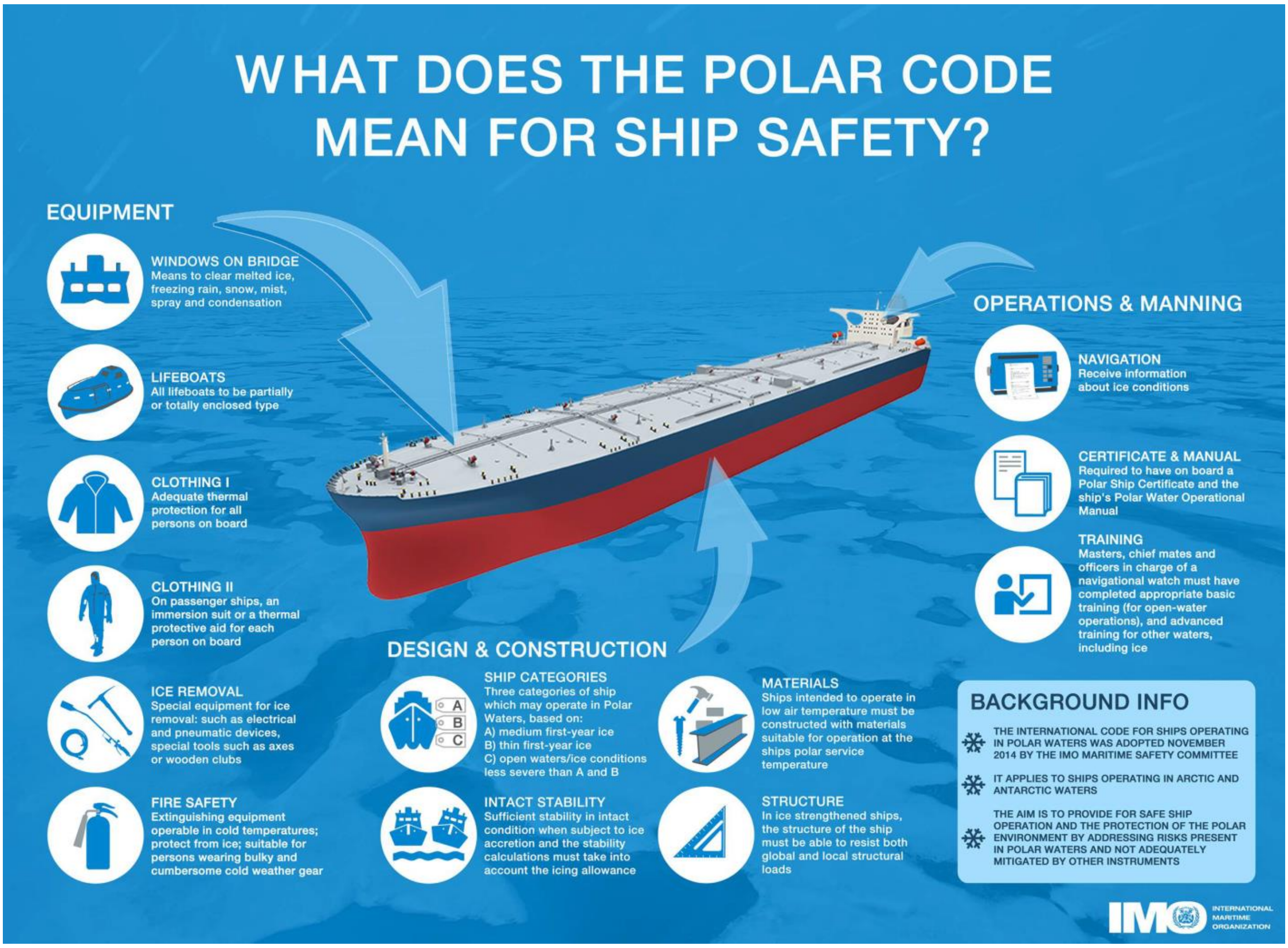

Figure 11. An illustrative guide to the ship safety components of the Polar Code designed by the IMO to promote awareness (Source: IMO[9]).

3.5 Future Opportunities

Future economic opportunities include capitalising on increasing Europe-bound traffic through the North Sea. The prospects of an ice-free Arctic have led to Stornoway Port Authority proposing their long-term vision to become an Arctic gateway hub in 20 years, due to their strategic location for European bound trans-Arctic shipping (BBC 2013; Mcbeth 2013). In 2016, China's COSCO shipping company (one of the world's largest) sent five vessels through the NSR, one of which delivered wind power equipment to the UK, becoming the third voyage to the UK via the NSR (Humpert 2016). Awarding the contract for the new Arctic research ship to UK shipbuilder Cammell Laird (Section 3.1) ensures that the UK retains its future readiness to construct specialist ice-class vessels.

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For the UK to fully capitalise on the potential future increase in Arctic shipping we may need to consider cooperation with other countries with common interests. Lloyd's Register (2015) surmise that the most tangible benefits of increased shipping in the Arctic to the UK maritime industry are an increase in UK passenger cruise voyages, increased export of natural resources, and the use of the UK's specialist maritime services. These interests are summarised in the following sections.

3.5.1 Passenger Cruise Voyages

There may be direct economic and/or employment benefits to the UK from an increase in passenger cruise voyages in the Arctic. Lloyd's Register (2015) envision these may arise from a combination of the following:

1. UK-registered cruise ships operating for passenger cruise voyages in the Arctic;
2. UK ports of embarkation for international passenger cruise voyages in the Arctic;
3. UK-domiciled specialist tour and expedition cruise operators.

Considering the relatively substantial UK and Ireland global market share, and the global prominence of UK embarkation ports like Southampton, it could be anticipated that increased numbers of UK and Ireland citizens will travel to the Arctic for passenger cruise voyages. Furthermore it is feasible that international customers may travel with UK operators on UK ships from UK ports to the Arctic as northern UK ports are closer in voyage distance to Arctic cruising destinations than most other popular European ports of embarkation.

3.5.2 Export of Natural Resources

Direct economic and/or employment benefits to the UK from increased export of natural resources from the Arctic (Table 3) could be anticipated in the case of one or a combination of the following Lloyd's Register (2015) scenarios:

1. UK import of natural resource cargoes from the Arctic;
2. UK-registered commercial ships employed to load natural resources from ports in the Arctic for export;
3. UK port trans-shipment of natural resource cargoes from the Arctic – transferring goods from Arctic ice-classed vessels to more southerly destinations on conventional carriers.

In the first scenario there is a possibility that UK buyers of natural resources from Arctic projects could be responsible for the provision of specialist Arctic shipping. Such a scenario is quite common for LNG cargoes where long-term agreements (typically with an international oil company) for the purchase of large volumes of LNG cargo are essential to justify huge investments in infrastructure.

The second scenario could be envisaged where Arctic minerals are imported to the UK on dedicated, purpose-designed and built, Arctic specification commercial ships (albeit highly dependent on commercially attractive terms for any minerals imported from the Arctic).

Table 3. Currently completed/operational/planned Arctic natural resource projects, their country, resource, date of operation, shipping season, and shipping vessel type and quantity. Adapted from Lloyd's Register (2015), project location map bottom. *Estimate

Area	Project	Resource	Date	Shipping season	Shipping demand
Canada	Polaris (Little Cornwallis Island)	Zinc	1971–2002	3 months	1 ice-breaking bulk carrier
	Raglan (Deception Bay)	Nickel	1997–present	8 months	1 ice-breaking bulk carrier
	Baffinland (Milne Inlet)	Iron Ore	2015–present	Year-round	3 ice-class bulk carriers*
	Baffinland (Steensby Port)	Iron Ore	2020*	Unknown	10-17 ice-breaking ore carriers*
US	Red Dog (Alaska)	Zinc	1987–current	4 months	23 ship calls/year
Russia	Norilsk Nickel Mine (Dudinka Port on Yensei River)	Nickel	1930s–Current	Year-round since 2005	5 ice-breaking container ships
	Prirazlomnoye (Pechora Sea)	Oil	2014–current	Year-round	2 ice-breaking oil tankers
	Varandey (Pechora Sea)	Oil	2008–current	Year-round	3 ice-breaking oil tankers
	Yamal LNG (Sabetta Port, Ob River)	Natural Gas	2016–current	Year-round	12-16 ice-breaking LNG carriers*
	Noviy Port (Ob bay)	Oil	2014–current	Year-round since 2016	6 ice-breaking oil tankers

Dashed lines represent seasonal export; yellow future projects

In the third scenario a UK port is developed for trans-shipment of natural resource cargoes from the Arctic, with direct economic and/or employment benefits to the UK. For example the Yamal LNG project reached an agreement in April 2014 for a Belgian LNG receiving terminal at Zeebrugge to act as a winter season LNG trans-shipment exchange port between Arctic specialised and conventional LNG carriers (Figure 12). This is a joint venture with China with a capital expenditure of $2.1bn, scheduled to deliver by 2018–2020 with LNG contracts sold through to 2045, and a requirement for 15 ice-breaking LNG carriers and 15 conventional trans-shipment LNG carriers. The UK has the capacity to emulate projects like this this with the largest LNG terminal in Europe on the Isle of Grain in Kent, with the capacity to receive, reload, and process 15 million tonnes of LNG a year, equivalent to 20 per cent of the UK gas demand (UKTI 2013).

3.5.3 Specialist UK Maritime Service Providers

The UK will likely continue to benefit from Arctic shipping through the provision of services and specialist equipment based in the UK to global entities involved in Arctic shipping. This may include, but is not restricted to:

1. specialist ship management services;
2. insurance and underwriting service provision, such as, for example specialist insurance for operations in Arctic seas provided by London-based underwriters;
3. technical services providers, such as, for example Classification and Certification services from Lloyd's Register;
4. specialist suppliers of equipment and materials.

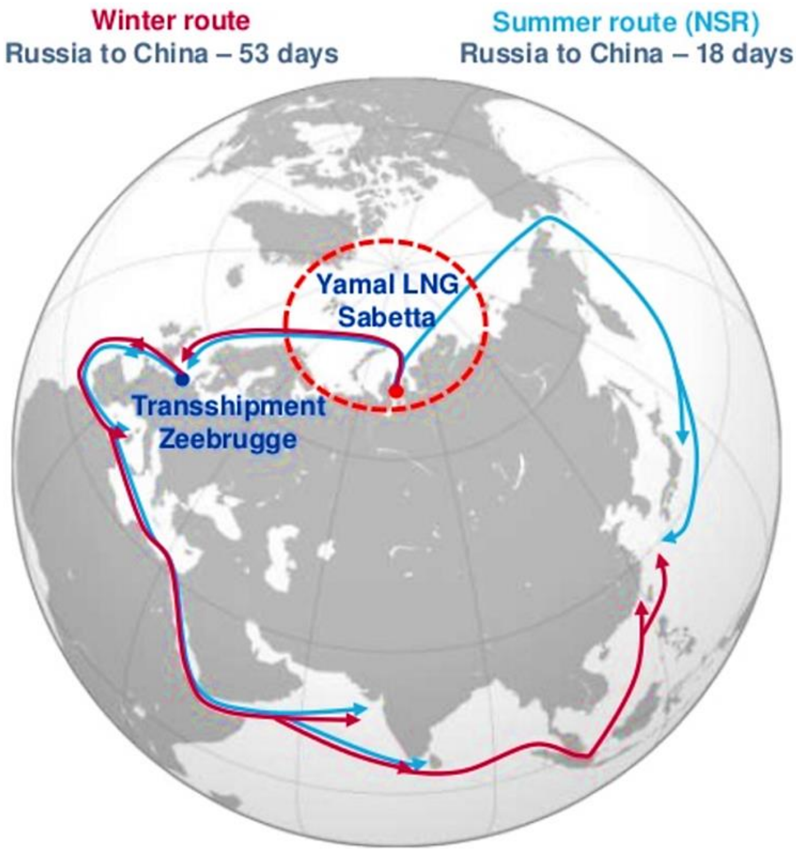

Figure 12. Yamal LNG export routes. Source: Teekay LNG

For many of these maritime services the UK and London is world leading. This highly skilled sector should continue to flourish if the commercial regulatory environment permits and London remains an attractive global hub.

3.6 Arctic Data Requirements for Informed Policy Decisions

Recent environmental changes in the Arctic are so pronounced that they have been identified despite incomplete and uncoordinated observing capabilities. The lack of adequate and coordinated pan-Arctic observations currently limits society's capability to identify, respond to and predict the geographic extent and severity of ongoing changes. A robust Arctic observation network is needed to address these limitations; such a network would be founded on existing platforms and observatories, starting with a set of key variables that are already measured at many locations but are not often collated (National Research Council 2006).

The UK leads the world in hydrography with the maps produced by the UK Hydrographic Office (UKHO) setting the international standard. Much of the Arctic lacks detailed hydrographic data, but upgrading existing charts is a comparatively low priority for the UKHO. The UK would benefit from supporting the improvement of charts for the Arctic not least to retain the UKHO's leadership, but also in fostering international partnerships. The Met Office is a world leader in weather forecasting and both the UKHO and the Met Office are ideally placed to provide world-class charting and forecasting services that could provide significant income streams for the UK (House of Lords 2015).

Better Arctic observations are required for safe tactical operations in the Arctic Ocean in addition to both scientific, and commercial strategic progress. The Government Response to the House of Lords (2015) Select Committee Report highlighted the importance of continued investment into ocean science and climate-modelling centres like the National Oceanography Centre and the Met Office, and science programmes like those coordinated by NERC's Arctic Office, to allow better predictions of the future Arctic.

4. Concluding Remarks

This report outlines the past and future changes to Arctic sea ice and the opportunities that this may afford local and global shipping, trade and industry, and government alike. The findings are summarised below along with the pertinent implications for policy makers.

4.1 Increased Navigability

4.1.1 Summary

- Currently the Northern Sea Route (NSR) and Northwest Passage (NWP) are seasonally open most years with minor ice-breaking support, with the trans-Arctic shipping season peaking in late summer. However in the first half of 21st century the shipping season on the NSR and NWP will remain variable and unreliable, continuing to require ice-classed vessels or ice-breaker escort during summer months.

- Increasing global and Arctic temperatures will continue to open Arctic routes more frequently and increase the Arctic shipping season length. Conditions on the NSR are easiest, with conditions on the NWP becoming similar about a decade later. The transpolar route (TSR) across the central Arctic Ocean should become available around mid-century. Voyages from UK to East Asia typically save 10–12 days using a trans-Arctic route compared to the Suez Canal route.

- By mid-century, for a greenhouse gas emissions mitigation scenario in line with the recent UN 'Paris' climate change agreements, the number of navigable days per season is 2.5 times greater than early-century; for 'BaU' greenhouse gas emissions scenario it is 3.5 times greater.

4.1.2 Implications

If anthropogenic greenhouse gas concentrations can be reduced sharply in line with the UN Paris climate change agreements, Arctic ice melt and shipping opportunities will still continue to increase for the majority of the 21st century. However, even with continually increasing greenhouse gas concentrations, climate models suggest there will always be some Arctic sea ice during winters through the 21st century. Although the Arctic shipping season length and reliability is likely to increase dramatically, for the vast majority of the current global shipping fleet sailing trans-Arctic will remain a seasonal endeavour. Based on the current activity and physical climate changes this suggests that trans-Arctic shipping is likely to increase, focused on the NSR; however, it is likely to remain a niche market for specialist operators.

4.2 Commercial Viability

4.2.1 Summary

- Incentives for trans-Arctic shipping include perceived economic savings from shorter global routes, and destinations for resource extraction and tourism. Challenges include risks from a testing environment, remoteness and lack of crew training.

- Academic literature on the economic viability of trans-Arctic shipping draws mixed conclusions, although most find it plausibly profitable. Trans-Arctic routes are unlikely to be economically viable for container traffic due to lack of en route ports providing networked economic opportunities. However, bulk shipping (unpackaged hold cargo such as ore, LNG, oil) can take advantage of the shorter trans-Arctic routes offered, due to more flexible schedules compared to container shipping.

- The Russian government wishes to develop the NSR as a commercial enterprise, and although they charge fees for its use they do offer substantial services such as ice-breaking support and pilotage. These are likely to remain necessary for the shoulder seasons and for future investment and development of the route.

4.2.2 Implications

Arctic routes will not replace traditional canal routes (Suez and Panama) in the 21st century, although they will likely be used for an increasing Arctic bulk and destination shipping market and may provide a seasonal supplement for non-Arctic specialists. Current commercial viability is focused on destination shipping, largely supplying increasing natural resource projects in the Arctic. The NSR will likely remain the most commercially popular area due to favourable sea-ice conditions, population and industry centres, and the proactivity of the Russian government in commercialising the route. Although tariffs for the use of the NSR are currently high, the management of the route is necessary for safety and productivity in the coming decades. It remains to be seen what impact the opening of the central Arctic TSR around mid-century will have on the NSR for trans-Arctic shipping, although destination shipping will certainly still centre on the NSR.

4.3 Considerations for the UK

4.3.1 Summary

- The UK has a leading role in Arctic science, and London is the global centre for maritime services. Half of the member states of the Arctic Council are also top 20 trading partners for the UK.

- The main provider of Arctic shipping is Russia, with Canada and the Scandinavian countries also having extensive expertise. Northern European industry and ports in the Netherlands, Germany and Belgium are also increasingly involved in projects requiring Arctic shipping.

- Arctic economic growth is focused in four key sectors – mineral resources, fisheries, logistics and tourism – all of which require shipping and could generate investment reaching $100bn or more in the Arctic region over the next decade. The UK enjoys a substantial global market share of cruise tourism, which presents realistic economic opportunities for the development of UK-based Arctic cruise tourism. The UK’s geographic location also makes it well placed for trans-shipment ports – transferring goods from Arctic ice-classed vessels to conventional carriers for more southerly destinations.

- The UK will likely continue to benefit from Arctic shipping through the provision of services and specialist equipment based in the UK to global entities involved in Arctic shipping. For many of these maritime services the UK and London are world leading. This highly skilled sector should continue to flourish if the commercial regulatory environment permits, and London remains an attractive global hub.

4.3.2 Implications

An increase in Arctic shipping presents many economic opportunities for the UK from increased use of London-based specialist services providers, Arctic cargoes, and cruise tourism. The UK is a world leader in Arctic science research, and continued investment would help the UK both directly and indirectly. The UK has considerable diplomatic influence through governance and commerce which could create strategic links to like-minded northern European nations and enhance the implementation and awareness of marine conventions, especially relevant for Arctic shipping such as UNCLOS, SOLAS, MARPOL and the Polar Code. The UK's extensive maritime expertise in fields such as science, technology, insurance, finance, legal and regulatory, could be capitalised on to maximise British influence and sustainable development of the Arctic.

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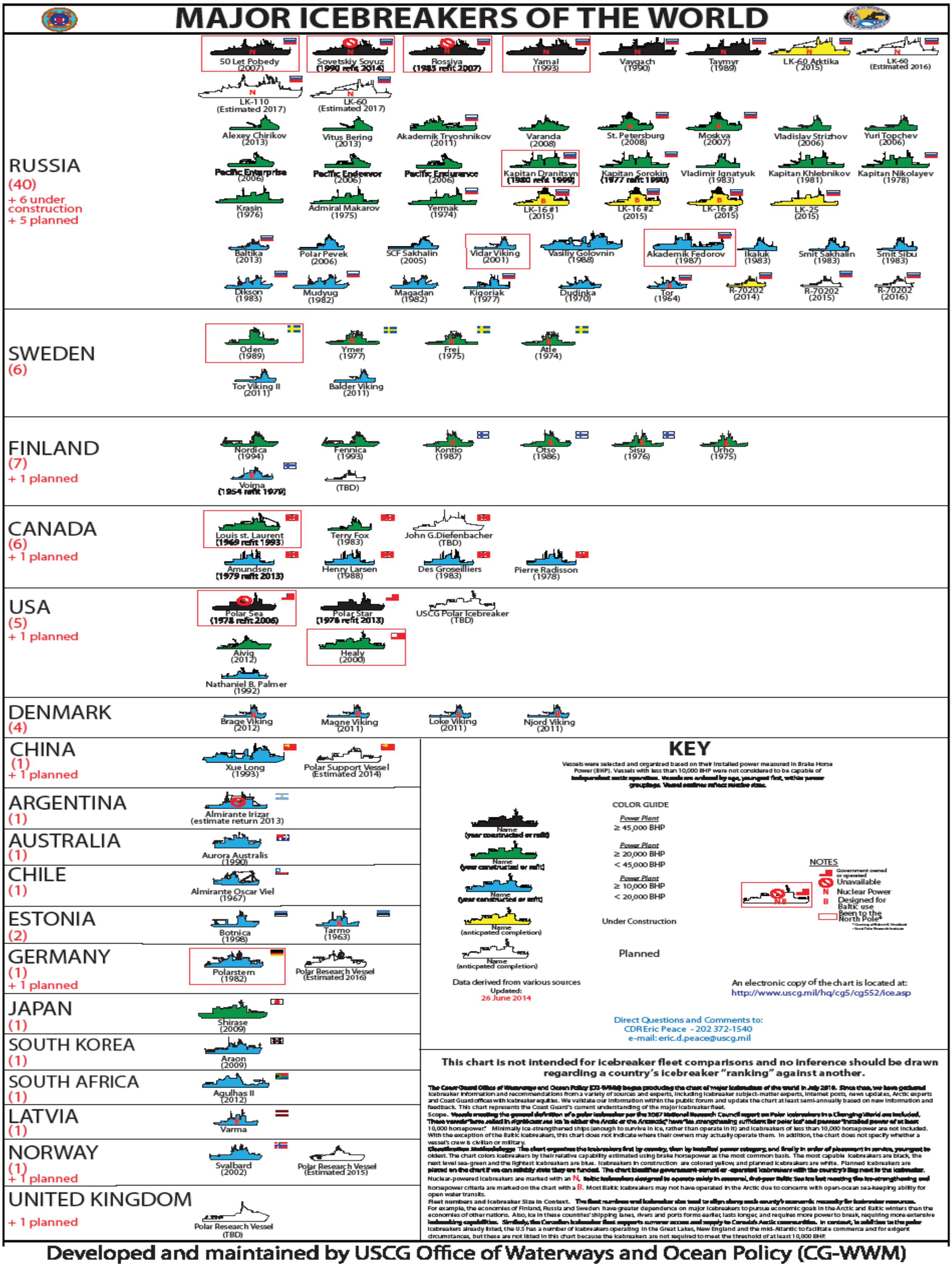
Appendix 1. Major Icebreakers of the World



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