Access in Flux: Opportunities and Uncertainties in Arctic Transport and Development

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1. Introduction

The IPCC-projected warming of 1.8-4°C (Solomon et al., 2007) globally over the next century is expected to precipitate unprecedented environmental change. This global temperature increase is likely to be strongly amplified in the Arctic (+2-9°C by 2100) as melting sea ice and reduced snow cover allow solar radiation to be increasingly absorbed by polar seas and landmasses (Anisimov et al., 2007). As a result, the Arctic is often viewed as a bellwether for global climate change, as thawing permafrost, melting glaciers and ice sheets, and sea ice recession signal the beginning of a warmer climate regime in the high latitudes (ACIA, 2004a). These physical changes have powerful implications for both marine and land-based transportation systems in the Arctic.

Economic development in the Arctic depends critically on access to remote resources and communities. Because resources are necessarily tied to specific places, development requires reliable and cost-effective connections between extraction sites and consumer markets. These connections are mediated by a dynamic, rapidly changing physical environment and sparse, environmentally sensitive infrastructural networks. Understanding accessibility in this region requires attention to two climatically sensitive transportation systems: marine transport in ice and terrestrial winter roads. Changes to these systems have important implications for community resupply (inward transport) and resource exploitation (outward transport), leading some Arctic settlements to become increasingly integrated with global economic networks, and others less integrated and effectively more remote.

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This paper will critically examine the economic implications of recent and future changes in Arctic accessibility in response to a warmer climate regime. While marine navigation seasons are expected to lengthen with continued sea ice recession, the degree to which increased access will enable economic and urban development in the region is highly uncertain. Furthermore, climate change may decrease terrestrial access in winter owing to reduced winter road potential. First, this paper will review the scientific basis underpinning projections of growing Arctic marine accessibility and the implications for resource extraction and transit shipping. The paper will then discuss the physical and economic challenges impeding Russian Arctic oil and gas development and transit shipping, followed by an examination of the impact of reduced terrestrial winter access on northern development and quality of life. The paper will close with a discussion of future development scenarios in Arctic Russia and infrastructural requirements for the creation of a transit shipping network based on the Northern Sea Route (NSR).

2. The “opening” of the Arctic?

There has been a growing consensus over the past decade that reduced sea ice extent will increase maritime access throughout the Arctic (ACIA, 2004a; Arctic Council, 2009). Satellite data collected since 1979 reveal a robust downward trend in summer ice extent and thickness (Maslanik et al., 2007; Comiso et al., 2008; Stroeve et al., 2012b) with record lows in 2007 and 2012 (NSIDC, 2012). Despite adverse consequences for the global environment, reduced sea ice is often portrayed as promoting economic opportunity and integration for the region. Projections of an ice-free Arctic in summer sometime in the next few decades (Wang and Overland, 2009) have fueled interest in trans-Arctic maritime routes linking major world markets. While the NSR has been utilized commercially for decades, recent research suggests that new theoretical “trans-polar” routes representing the shortest marine distance between Europe and East Asia may become technically viable by mid-century (Smith and Stephenson, 2013). Circumnavigating overland canals and other narrow waterways such as the straits of Malacca and Hormuz bestows the added advantage of avoiding strategic “choke points” that may be blocked for political reasons or unreliable due to pirate activity.
Oil and gas are currently produced in four Arctic states (Canada, Norway, Russia, and the U.S.) which together account for approximately 28% of world oil and 46% of gas output (BP, 2011). A widely-cited USGS study estimates that the Arctic contains 13% of the world’s undiscovered oil and 30% of its gas, approximately 84% of which is under exclusive state control less than 200 nautical miles from shore (Bird et al., 2008; Gautier et al., 2009). One-third of the undiscovered oil (30 billion barrels) is in Alaska, while one-third of the undiscovered gas is in Russia’s West Siberian Basin. In aggregate, Arctic hydrocarbons represent one of the most significant remaining unexploited sources of nonrenewable energy.

In response to new economic prospects, sea traffic in the Arctic has increased in recent years to levels unprecedented in the post-Cold War era. Resource exploitation, community resupply, and tourism are expected to increase considerably over the next decade (Arctic Council, 2009). Voyages via the NSR are occurring increasingly later in the navigation season, as demonstrated by the first-ever transit by an LNG carrier in November 2012 (McGrath, 2012). Using modeled sea ice concentration and thickness, Stephenson et al. (2011; 2013) showed that large areas of the Arctic are projected to rise in accessibility to Polar Class vessels by mid-century, including a majority of the Russian coastal seas in summer. Navigation season in the NSR is projected to exceed 3 months on average throughout the 21st century using such vessels, while winter access will remain limited to ice-strengthened vessels, as even the most aggressive climate models predict winter ice cover throughout the 21st century (Stroeve et al., 2012a).

3. Tempering optimism

While a seasonally ice-free Arctic appears likely in the coming decades, whether attendant marine access will enable economic and urban development in the region is highly uncertain. Arctic oil and gas plays remain among the most expensive to develop in the world and carry considerable environmental risks, particularly offshore (Mulherin et al., 1996; ACIA, 2004b). Data from Alaska’s North Slope indicate that the cost of drilling an onshore well in the Arctic may be as much as 640% higher than the U.S. average (EIA, 2008). Furthermore, costs have risen sharply in the last decade as new exploration has turned toward increasingly remote and marginal fields. From 2000 to 2005, onshore drilling costs in Alaska rose 564%, compared
with 165% for the U.S. as a whole (American Petroleum Institute, 2006). Offshore wells are many times more expensive in the Arctic (~$60 million; Chukchi Sea) than at lower latitudes (~$7 million; Gulf of Mexico) (Østreng, 2012). Where infrastructure is underlain by permafrost, climate change-induced subsidence and thickening of the seasonal active layer increase construction and maintenance costs further (Streletskiy et al., 2012a; Streletskiy et al., 2012b).

Climate change also presents numerous challenges to navigation and regional accessibility even as it reduces overall ice extent. A longer ice-free season may increase the likelihood of storms and ice velocity in coastal waters due to increased wind fetch (Barber et al., 2010). The risk of ice collisions in such environments may be greater than in calm, ice-covered seas in which ice drift is relatively slow and predictable. Remaining multi-year ice may move from the central Arctic Ocean toward shipping lanes, creating a hazard to all but the most ice-strengthened ships (Melling, 2002; Howell and Yackel, 2004). Warmer temperatures also promote higher humidity, resulting in fog and reduced visibility. Furthermore, ports and other land-based infrastructure will have to contend with coastal erosion caused by permafrost thaw, limiting the support available to passing vessels.

The environmental impact of an oil spill in the Arctic would be especially severe. Sea ice, low visibility, high winds, rough seas and cold temperatures complicate all aspects of spill response (Pew Environment Group, 2010). Oil may remain on or within sea ice after a spill only to be released months later (Atlas et al., 1978; Martin, 1979). Such “trapped” oil is difficult to track and cannot be reclaimed using conventional methods (AMAP, 2007; Pew Environment Group, 2010). Furthermore, vulnerability to spills is not limited to areas of extractive activity or oil shipment corridors. Many vessels, particularly those operating in the eastern Arctic, continue to rely on low-cost heavy fuel oil (HFO). Accidents involving these ships may cause spills regardless of the cargo on board (Det Norske Veritas, 2011).

The fate of new oil and gas development in Russia is ambiguous. New unconventional deposits such as shale gas, shale oil and oil sands, as well as new conventional production made possible by horizontal drilling techniques have dramatically increased supplies from fields relatively close to markets and transport infrastructure. Such plays are meeting demand that otherwise would have justified Arctic investment. The Shtokman project, for example, had been
intended to supply LNG to the U.S. but has been delayed indefinitely after hydraulic fracturing became widespread in North America. The project may be revived for export to East Asian markets, but the necessary transport infrastructure and LNG plants have not yet been built. New conventional and unconventional supplies from around the world, combined with the high costs and long lead times of Arctic production, mean that Arctic hydrocarbon development will be highly dependent on oil and gas prices determined in large part by global demand. In light of these challenges, Russian cities hoping to capture a share of revenue from petroleum and transit activities must adjust expectations toward a reality of persistent high operating costs and an uncertain pace of development. While Arctic marine traffic is certain to increase as the navigation season expands, Russian claims that the NSR will soon rival the Suez Canal as a global shipping corridor are exaggerated. In the near term, Arctic routes will be ill-suited to container shipping, which prioritizes reliability and economies of scale over speed and is increasingly driven by just-in-time production models. Shipping schedules on Arctic routes must account for unpredictable weather and ice conditions, leading to delays and supply chain disruptions. Traffic related to within-Arctic resource extraction is likely to constitute the vast majority of Arctic shipping activity in the first half of the 21st century.

4. Winter roads

Climate change also has powerful implications for terrestrial accessibility in the north. Because of the scarcity and high cost of permanent roads in the Arctic and sub-Arctic, terrestrial access is often made possible by seasonal winter/ice roads, constructed either by removing snow from frozen land and water bodies and applying water in layers to form smooth ice (Cardinal, 2011) or by packing snow to construct a workable driving surface (Adam, 1978). Land cover that remains impassible from spring to fall, such as boggy muskeg and peatlands covering vast areas of northern Russia and Canada, becomes accessible in winter in this way. The substantially lower cost of winter roads (~$5000/km vs. ~$1 million/km for permanent roads; heavy freight) makes them attractive as precursors to permanent roads in industrial operations or long-term solutions in remote communities (Guyer and Keating, 2005; Zaitsoff, 2011). As a
result, winter roads have become a vital part of the resource development sector throughout the Arctic and sub-Arctic.

Winter roads are also used extensively for community resupply. In Russia, such connections (usually called “ice roads”) often take the form of river ice crossings (Tananaev, 2013). For example, an ice road crosses the Ob River linking Labytnangi and Salekhard in the Yamalo-Nenets Autonomous Okrug. Yakutsk is connected south to the Amur region via the Lena Federal Highway and east to Magadan via the Kolyma Federal Highway by ice roads that cross the Lena River. These highways are open year-round and connect to Yakutsk by ferry in summer and by ice roads in winter. Hundreds of such crossings link communities throughout Siberia, of which 30 to 40 are opened officially every winter in Yakutia. Ice roads are normally open from December to April with the northernmost roads closing in early May. After closing, winter roads return to an impassible state and resupply make take place only by air or river barge.

Use of winter roads depends on sub-zero temperatures to maintain ground strength and ice thickness. Warmer temperatures can delay the opening and advance the closing date of winter road operation; therefore, long-term warming trend implies a future of shorter winter road seasons and reduced terrestrial access. Stephenson et al. (2011) modeled the impact of future warming on winter road access, and found a broad pattern of winter road suitability loss from October to May in all Arctic states by mid-century, particularly in Russia and Canada. Losses are especially pronounced in April and November, months representing the “margins” of the operating season in which winter roads typically open and close, respectively. These projections suggest longer travel times near Arctic settlements, especially when combined with rugged terrain and infrastructure scarcity.

Reduced winter road access has numerous negative consequences for communities and industry. Often, winter roads are the only land links around and between remote settlements, such as Olenek and Mirny in northwestern Yakutia (Tananaev, 2013). A shortened winter road season implies higher costs in these impacted areas. When winter roads fail, overland travel may become dangerous or impossible, as drivers may become trapped in muskeg or fall through river or lake ice. Unless located near a navigable waterway, communities face steep price increases when winter roads close as supplies must be delivered by air. Likewise, mining,
energy and timber interests face shorter time windows to transport necessary equipment and product. This may lessen the attractiveness of exploitation in remote areas, potentially requiring costly investment in permanent roads and/or maritime port facilities. Interannual variability in winter road season length may complicate supply chain coordination, leading to production inefficiencies that may render industrial activities uneconomic. Thus, companies that use winter roads must be able to adapt to both interannual variability in season length in the short term and a truncated average season in the long term.

5. Infrastructure and future development

Given the aforementioned climatic and economic uncertainties, one might envision several scenarios of development in Arctic Russia. One is that persistent and unpredictable sea ice conditions and rising global oil and gas supplies stymie the creation of an Arctic marine transit network based on the NSR. An opposing scenario sees rapid decline in ice extent and attendant expansion of the navigation season combined with high oil prices precipitating massive investment in infrastructure and build-out of Arctic ports, leading to rapid oil and gas development. In this latter scenario, such investment will occur where economic incentives are present and where infrastructure fulfills a strategic or commercial objective. The concentration and seasonal duration of sea ice then become mitigating factors rather than primary determinants of shipping, as demonstrated by the rapid construction of an LNG export plant in Sabetta on the Yamal Peninsula coast. Even though ice is present most of the year in the Ob Bay, construction is ahead of schedule due to government investment exceeding 47 billion RUB, with the goal of increasing total Russian LNG output by more than double (Staalesen, 2012). Similar future infrastructural expansions will depend on the existence of a market basis for investment, bolstered by proximity to resources and existing supply lines. It is thus plausible that Naryan Mar, situated on the seasonally ice-free Pechora Sea with close proximity to the Varandey oil terminal and Prirazlomnoye offshore oil field, will be the target of future investment while Tiksi, located far from planned hydrocarbon projects and potential NSR transshipment hubs, will not. Whereas NSR infrastructure in the Soviet period was developed to be independent of international commodity flows, new infrastructure will be built to capitalize on opportunities
created by these same flows. In this way, NSR infrastructure is likely to expand as a series of targeted, concentrated investments rather than a proliferation of ports following historical settlement patterns.

If shipping related to both transit and petroleum activities continues apace, substantial infrastructural upgrades will be required throughout the NSR. Many ports and support infrastructure along the NSR fell into disrepair following the Soviet Union’s collapse, and the communities that maintained these facilities experienced severe outmigration (Heleniak, 2008). This infrastructure would have to be rebuilt or repaired with a replenished workforce in order to sustain a concentrated expansion of NSR shipping. Such upgrades at ports include deepwater berths, cranes, refueling stations, intermodal transfer facilities, storage tanks and warehouses, worker accommodations, and medical facilities. Weather and ice monitoring, firefighting and rescue stations will be required throughout the NSR to help prevent and respond to emergencies. Drilling platforms, disaster response vessels and spill cleanup equipment that operate year-round must be built to withstand ice impacts. Building such infrastructure may require buy-in from foreign companies in the form of capital and expertise. Buoyed by the widely-hailed 2010 Barents Sea boundary agreement, Russian and Norwegian companies are signing joint ventures to develop Russian fields in the Barents Sea (Kolyandr, 2012). Such partnerships make sense in light of the considerable technical advantages Norway possesses in the oil and gas sector (Stephenson, 2012).

6. Conclusion

Transportation systems in the Arctic will undergo profound changes in the coming decades. Observed and projected trends in sea ice recession have made it increasingly apparent that marine access will continue to rise throughout the Arctic for most vessel types in summer, while vessels with some icebreaking capability will have expanded access year-round. However, considerable uncertainties remain about the economic impacts of these changes. Resource extraction and transit shipping remain risky and expensive enterprises in the Arctic, owing to high infrastructural costs, commodity price fluctuations, navigation season uncertainty, and potentially severe environmental impacts. Furthermore, climate warming presents an economic
vulnerability to inland northern communities and industry by reducing terrestrial accessibility afforded by winter roads. Resource development and transit shipping will require considerable investments in infrastructure in order to operate safely and adapt to the needs of a changing global economy. While shipping is likely to continue to increase in the near term, it may be many years before Arctic cities become fully integrated within global resource and transportation networks. The dual uncertainties of climate change and resource economics form a critical backdrop against which questions of Arctic development will continue to evolve.
References


