# ‘Icy Futures’: Carving the Northern Sea Route

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I declare that this thesis is my own work, and has not been submitted in substantially the same form for the reward of a higher degree elsewhere.

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Abstract

The research examines intersections between globalisation and climate change in the (re)emergence of a 'Northern Sea Route' through the Russian Arctic, which some speculate could soon rival or replace the Suez Canal as major global trade artery. The research explores shifts in the contemporary shipping system, a relatively underexplored area of mobilities research, examining the affordances and risks posed to shipping and resource extraction activities by melting Arctic sea-ice, as sections of the maritime Arctic become increasingly integrated into global circuits. The research examines actual and potential developments surrounding the Northern Sea Route (NSR) in the Russian Arctic, examining the ways geopolitics, geoeconomics and geophysical processes collide in the ‘Anthropocene Arctic’.

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## Contents

**Preface/Acknowledgements**

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## Chapter one: introduction

In 2007, Arctic sea-ice shrank to 4.3 million kilometres, then the lowest extent ever recorded by scientists. In 2012 this record was itself smashed as the ice extent reached a new low of 3.41 million kilometres. Surface and air temperatures are rising in the Arctic at roughly twice the rate of the rest of the world, due to regional amplifications of global climate change processes (Jeffries et al 10-14).

A year after 2012's spectacular melt, a Hong-Kong flagged vessel owned and operated by a Chinese firm set sail from Dalian in north eastern China, bound for Rotterdam, Holland, transporting a cargo of steel and equipment. Rather than sail through the Suez Canal like most ships headed for Europe from Asia, *Yong Sheng* travelled via the Arctic, shaving 12 days off the journey.

Sometime this century, the Arctic will be completely ice-free during the summer months (Wadhams 2016: chapter one). It will then be possible to traverse the North Pole in a canoe. Currently however, moving through Arctic waters requires ice-breaker assistance and the mobilisation of tremendous human, non-human and financial resources. The research examines intersections between globalisation, climate change, resource extraction, and shipping mobilities.

Attempts to find a short-cut connecting Europe to China via the Arctic date back to the 1500s. Explorers such as Hugh Willoughby in 1553 and later John Franklin in 1885 made famous (and in the latter case doomed) attempts to search for the Northeast and Northwest Passages respectively. The story of the search for these routes is littered with disasters and failed attempts to conquer these most recalcitrant of spaces (Craciun 2009).

In the 21st century these passages are remerging as objects of governance and contestation. Melting ice is routinely figured as providing opportunities, in the context of a congested and vulnerable global shipping system approaching its limits, to accelerate and insulate East-West cargo flows from disruptions such as piracy, as well as provide distribution paths for resources, especially gas, being extracted from under the Arctic.

Traffic along what has come to be known as the ‘NSR’ (Northern Sea Route) along Russia’s northern coast doubled every year between 2010 and 2013 (Ruiz et al 2014), leading many to ponder whether these were signals of an impending, irreversible, and ‘game-changing’ shift in the global shipping system.

The emergence of circumpolar shipping routes could utterly transform global trade geographies, linking cities, states, businesses, resources, components and marine biota in new ways – drawing together the previously dispersed and establishing new selectively connected spatialities or ‘power-geometries’ (Massey 1993) - in ways similar perhaps to containerisation, the construction of the Suez and Panama canals, or even the establishment of sea routes to Asia and the Americas by Europeans during the ‘long sixteenth century’ – a period of nautical exploration increasingly figured as inaugurating contemporary globalisation (Sloterdijk 2013; Moore 2016).

These routes involve a profound spatial re-orientation. When apprehended with the Arctic at its centre - and with this centre conceived not as an insurmountable obstacle or barrier but as a connecting space, the ‘distance’ between say Norway and Japan is closed, and some of the most ‘remote’ or peripheral places and ports on earth come to inhabit central locations. Harnessing the earth’s affordances in this way has been difficult to achieve on any scale due to the thick sea-ice which poses such a formidable obstacle to navigation, as well as the lack of infrastructure, uncharted territory and sizeable human population centres necessary to anchor the route.

Highly publicised journeys like that of the *Yong Sheng*, which typically involved some combination of European, Asian and Russian state and commercial actors, testified to and showcased new infrastructures and transnational partnerships. They were undoubtedly ‘demonstration’ voyages designed to publicise the NSR and promote the nexus of states, organisations, and specialist shipping services that could stand to benefit directly from increased shipping through the NSR, or indirectly through publicising and raising the profile of the many involved parties. Whether such journeys turn out retrospectively to have been faint signals of some impending ‘tipping point’ (Gladwell 2004) in maritime traffic and global trade patterns, or whether such voyages were merely random deviations of little global or enduring significance, the highly publicised journeys across the NSR occurring between 2010 and 2013 were moments of disruption, providing an opening for exploring the routes and routines which underpin modern urban societies, but which usually lie below the threshold of collective conscious awareness. Thus, similar to moments of break-down, and indeed linked inextricably to moments of break-down, the emergence of Arctic shipping routes opens up a space for closer examination of the ‘hidden network’ of cargo shipping, as well as the teleconnections and atmospheric energy transfers that link the Arctic to the rest of the world, in circuits.

Whilst the Arctic ‘is routinely cited as a place most likely to cause alarm and indeed shock amongst the climate change and policy-making communities’ (Dodds, Nuttall 2015: 50), it is also conversely a source of profound hope, regarding the new opportunities thought to be provided by melting ice, especially for closely linked resource extraction and logistics enterprises. Alongside ‘catastrophist’ narratives in which anthropogenically induced changes occurring in the Arctic - the very emblem of an unspoilt or ‘pristine’ nature (Cronon 1997) – illustrate industrial societies’ pathos and signals impending socio-ecological collapse, are utopian hopes and expectations regarding the accessibility of routes and resources, and the possibilities for commercial exploitation and geopolitical influence these routes and resources are seen to present.

The significance or gravity that Arctic shipping routes will come to exert over global social processes in the future is impossible to foresee from the limited point of view of the present. Nevertheless, in the following chapters I explore its ‘story so far’, mapping its emergence, history and potentials. The route has an especially precarious character, both in terms of the hazards, obstacles and risks with which it is associated, and in terms of its fluctuating patterns of use. But the NSR also has an enduring character, an extraordinary ability to ‘hail’ successive waves of merchants, seafarers and statesmen.

I begin by charting the main ‘drivers’ which in a broad sense, are coming together to ‘carve open’ the NSR; disruptions and blockages (or perceived disruptions and blockages) in the global shipping system, the development of Arctic resources, and regionally amplified global climate change processes. ‘Arctic Paradox’, feedback loops whereby heating makes possible more extraction and transportation which contributes (disproportionately in the case of Arctic carbon emissions) to further heating.

**Globalisation, cargo shipping and climate change**

Cargo shipping traffic increased fourfold between 1992 and 2012, largely as a result of increases in China’s manufacturing exports (Tournadre 2014). There are now many more ships currently plying the world ‘sea lanes’ than there were just a few decades ago. Imperatives to accelerate the turnover of goods and capital have resulted in bigger vessels, able to the carry ever-increasing volumes of containers, oil, gas, steel, nickel and other resources which are central to modern manufacturing, but which geological forces distribute unevenly across the Earth. The constant circulation of fossil fuels energy – transported largely across the oceans make possible almost all other circulations on which cotemporary societies rest.

The world's largest ship is the size of four football fields and can carry 19, 000 twenty-foot cargo containers. The world's largest tankers, known as 'Ultra Large Crude Tankers' have an overall length of around 380 metres and a cargo capacity of over of 3 million barrels of oil (EIA 2014). As a result, the narrow passages which provide economical links between centres of production and consumption, like Panama, Suez, Hormuz and Malacca, have become as much obstacles to global trade as facilitators of it. Constant upgrades and expansions are required to handle ever-increasing volumes of freight. The Suez Canal has recently been widened and a new land added, and the Panama Canal's expansion is expected to be completed in 2016 (Savitzky 2015).

The geographies of trade now seem subject to the same accelerated cycles of upgrade and obsolescence as the goods that move through them.  Like so much of the politics of contemporary mobilities, congestion and potential congestion plays a central role. The expansion of Panama, scheduled for completion next year, has triggered a wave of frenetic dredging activity along the Atlantic coast, as ports are forced to expand or face losing traffic to competitors. The Port of New York alone has moved some 42 million cubic yards of dirt over a decade in anticipation of the opening of an expanded Panama Canal (Maly 2015; Carse, Lewis 2016).

Whilst one tendency in shipping is the expansion of ships, canals and ports, another is the creation of new routes, or the re-tracings and re-imaginings of old routes. Imperatives to relieve congestion and smooth the flow of commodities, as well as provide insulation from the new forms of maritime piracy that have accompanied this growth in seaborne trade, are driving the development of alternative routes like the new Chinese-backed Silk Road initiatives, and the Russian-backed Northern Sea Route through the Arctic. These shifts are intersecting with climate change processes in driving development of Arctic shipping.

The consequences of heating processes that have been underway for some time are beginning to be registered, and bubbling-up into public consciousness. Climate change 'impacts' are already occurring, although they are difficult to disentangle from extant processes. For instance, climate change processes are thought to be implicated in the current Mediterranean refugee crisis, due to the prolonged droughts that ravaged Syria's farmland from 2007 to 2010, leading to one of the biggest displacements of people of modern times (Kelley et al 2015). 'Historians may look at the year 2015 as the year that shit really started hitting the fan', states a piece in Rolling Stone magazine. Record-setting heat waves in Pakistan and India killed more than 1,000 people, the East coast of the US witnessed unprecedented cold and snowy weather, and London reached 98 degrees Fahrenheit during the hottest July day ever recorded in the U.K (Holthaus 2015: no page).

Many of these changes are thought to be connected to changes taking place in the Arctic, and the consequences this has had on the path of the Polar Jet Stream, which has started to meander and move more erratically, with consequences for weather patterns in far-away places (Francis, Vavrus 2015). The Earth's snow and ice regions, or the cryosphere are highly sensitive to variations in temperature (Marshall 2011). Melting ice in the form of calving glaciers will force global sea level rises with likely major implications for societies. There is thus an urgent need for social research on relations between societies and the ocean-spaces and hydrological circuits that both sustain and imperial them, relations between people and water, in its varying manifestations.

Other forms of life are on the move, adapting in 'real time' to the warming ocean. In the winter of 2013-2014, a massive eruption of snowy owls, which spend most of their time in the Arctic and subarctic regions, journeyed south unexpectedly, likely due to declining populations of lemmings on which the owls feed, leading to collisions with aircraft as far south as Kennedy and Newark airports (Struzik 2014), Simultaneously, attracted by less icy waters and longer navigation seasons, ships are appearing further north in greater numbers, along with fleets of drill rigs, oil and gas fields and pipelines. These cascades and 'collisions' resulting from ice-loss bring into relief the fundamentally global, mobile and entangled character of social and ecological life. By disrupting routine patterns of movement, these shifts draw attention to the central role of circulations of all kinds.

The Russian state claims sovereign rights over the NSR and seek to capture traffic and trade flows, given the substantial revenues generated by Russian ice-breaker escorts. Like the Suez Canal, the emergence of Arctic shipping routes entail the large-scale reshaping (what we might call a kind of 'terraforming') of the Earth by trade, transport and industrial activity, although unlike Suez this reshaping is not the result of deliberate action.  Yet unlike the Suez Canal, completed in 1869, the carving of the NSR involves not the construction of a literal passage, but the development of a range of surrounding infrastructures, ice-breakers, ports, regulations, hydrographical support and satellite systems, which together enact the route. The 'object' at the core of this study then is multiple and dispersed. Although it may be legally defined, a 'sea route' does not take a material form in the same way as say a road, pipeline or canal (Ingold 2007: chapter 2), thus enabling overlapping and at times competing and contradictory definitions. There are many 'northern sea routes'.

There are three Arctic sea routes, which have been subject to varying levels of development (figure 1.2); these routes can be seen as efforts by human collectives to *domesticate* dangerous Arctic sea spaces. There is the almost purely hypothetical Transpolar Route across the North Pole, the underdeveloped Northwest Passage across the 'Canadian' Arctic and the Northern Sea Route (formerly the Northeast

Passage) across the ‘Russian’ Arctic. The Northern Sea Route (NSR) is witnessing the greatest traffic increases and the most sustained development, largely due to the legacies of the Soviet Union’s industrialisation of its Arctic and Far Eastern territories during the 20th century, and due to the route’s proximity (it is thought) to large quantities of undersea hydrocarbon resources. Largely ‘forgotten’ 20th century developments have unexpectedly become significant once more, as abandoned and semi-derelict Soviet-era maritime infrastructure now provides a minimum ‘foothold’ for further activity and development of the route.

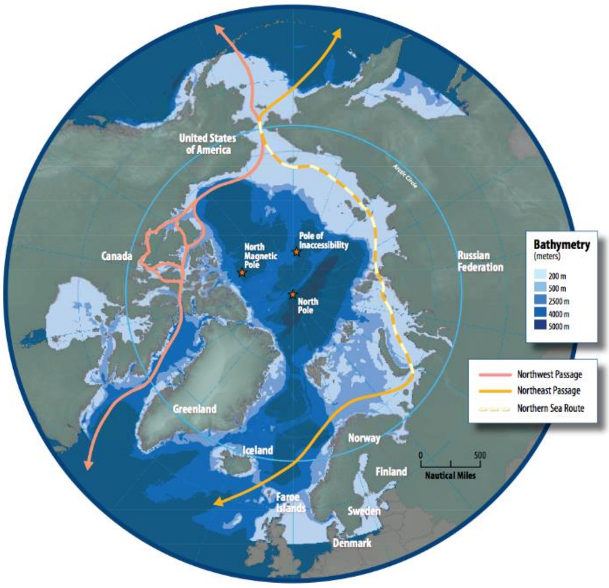


Figure 1.2 Map showing the NSR (in white), NWP (red (blue). Source: https://en.wikipedia.org/wiki/Northern_Sea_Route

The carving of the NSR involves the conjoining of maritime, underground and orbital spaces, logistic orchestration and coordination of ‘military’ proportions (including complex engagement with the elements through increasingly refined forms of weather forecasting), social and geopolitical contestation (and often the literal presence of militaries), new risks and insecurities, and the ‘mining’ of previous geological eras (Clark 2016). Unlike most cargo and energy routes, Arctic sea routes are highly experimental. These routes have not yet become *routine* we might say, and indeed due to the danger associated with moving through the Arctic, are a source of tremendous fascination and indeed ‘fetish’. There would appear to be an affective investment in Arctic shipping routes which overflows the boundaries of economic rationality. The remainder of this introductory chapter take us through key recurring themes, before concluding with a brief discussion of the three ‘reorientations’ performed by the research.

**Anthropocene, routes, resources and routines**

The feedback loops between resource extraction, the waste outputs of travel, atmospheric $C0_2$ accumulations, melting ice and further resource extraction and transportation affordances, are primary exemplars of what some scientists refer to as a new geologic era, the ‘anthropocene’ (Crutzen 2002; Zalasiewicz 2009; Hamilton 2014; Lewis, Maslin 2015; Waters et al 2016). The ‘anthropocene’ designates a new planetary epoch in which human collectives have become the hegemonic force on ‘Earth’, shaping current and future conditions for nearly all life. Although the precise origins of this new era are a source of serious contention, significant evidence can be mobilised in support of the dates 1492-1610 as marking the inauguration of the anthropocene (Lewis, Maslin 2015). This was the period of European colonial expansion and the establishment of a global network of maritime trade routes, and a spatial division of labour stretching all the way from Asia to the Americas. Through this network circulated not only people, culture and cargo; the most significant exchange from a geologic point of view was the remixing of the planet’s marine biota, an unambiguous and ‘permanent change to the Earth system’ (Lewis, Maslin 2015: 155). Yet this turning point in Earth system history will perhaps prove to be outmatched in significance by the post-WW2 ‘Great Acceleration’ (Steffen et al 2015), discussed further in chapter two.

Routes are etched into the thesis. Mundane everyday practices such as filling up at the petrol station, plugging-into the wall, or switching on the heating presuppose the availability of natural resources, and paths linking to these resources. Such activities therefore involve the carving of many routes which remain invisible to most people. Routes are wormholes that draw distant places together. Partly these routes are invisible as they are often out of sight (e.g. underground conduits, sea lanes), but partly they are hidden in plain sight, too obvious and mundane to be of any interest, unlike the world of symbols, signs and meanings that preoccupy people. Routes might be said to form part of a 'material unconscious'. Routes are in between or on the way to other places, and for that reason are often rendered marginal relative to the destinations at which people and things come to rest. Through routes human and other animals domesticate spaces and carve out territories. Filling-up at the petrol station or plugging into the wall, entail not only the carving of *actual* paths and supply lines, for instance the network of oil wells, pipelines, refineries, tankers, shipping lanes, through which petrol was extracted, processed, delivered and pumped into a car. There are also routes, like the NSR and new Silk Roads, that are being developed and 'trialled' *in anticipation* of blockage and disruption along existing routes. These experimental passages enjoy a relatively high degree of visibility compared with the routine passages through which 'stuff' is transported to concentrations of people.

A central feature of the anthropocene is the *expansion* of anthropogenic activities, the 'filling out' and 'filling-in' of new spaces and territories - upwards, downwards, inwards, outwards – whether through colonisation, the establishment of infrastructure, or the production of seeping 'wastes'. The most unremarkable, taken-for-granted and mundane social activities presuppose events and produce effects which jumble or juxtapose an impressive assortment of times, spaces and materials, and cut-across cross vast spatial and temporal 'distances'. Ever widening ships and canals are both metaphors for such expansion processes but also literal embodiments of it. This expansionism is temporal as well as spatial reaching into geological time and producing consequences that last far into the future. The Anthropocene calls on us to recognise both the extent to which human collectives have come to permeate the non-human world, and the extent to which human collectives are themselves *permeated by* non-humans, who harbour capacities to disturb, modify, block or otherwise alter the course of events.

**Elements, tipping points, boundary crossings and futures**

The research foregrounds societies' entanglements with a range of non-human forces (e.g. Whatmore 2003; Braun, Castree 2005; Latour 2007). Highlighted is the enmeshment of people, places and politics in a world of 'elements', earth, water, air, and fire. Nearly all developments documented in the research are a consequence of – or heavily related to – the astounding gravity exerted over the world by fiery fossil fuel combustion processes. Ice is both central material and metaphor. Ice is both something that freezes, blocks and preserves, as well as something that is fleeting, unpredictable and liable to shift state. Materials are not mute or static but dynamic, energetically open to each other. A particularly vibrant materiality is embodied in water, which is the only material on earth which exists (without human interference) in solid, liquid and gaseous forms (Strang 2004; Stienberg et al 2014).

'Tipping points' (Gladwell 2004) or indeed 'tipping elements' (Lenton et al 2008) are also key. A tipping point can be defined as a critical point in an evolving situation that leads to new and irreversible developments. In written testimony presented to US congress in 2007, Charles Zender proffered that: 'nothing in climate is more aptly described as a 'tipping point' than the 0 °C boundary that separates frozen from liquid water' (Zender testimony 2007). Slight variations in temperature can lead to 'the same' material substance manifesting in radically opposing form, with dramatic consequences for life on the planet, including social and economic life. Tipping points can only be defined as such retrospectively, such that there is no way of knowing, at present, whether ‘demonstration’ voyages like that of the *Yong Sheng* are early signals of radical changes or not.

Predictions of continued melting are being used to drum-up a sense of optimism and hype regarding the future viability of the NSR, demonstrating strange links between climate modelling, and the production of climate change itself, as ‘the scientific tools used to predict new transportation opportunities overlap closely with those tracking the diminishing annual concentrations of sea ice’ (Bravo, Rees 2006: 205). Maritime trade geographies are continually under construction. Drummed up by their architects and promoters, there is also a sense of ‘hype’ that is built around these projects, which invariably all promise to ‘transform global trade’. In contrast this research examines the actually existing NSR, which has a promissory character but remains unfinished, which could go in many different directions or not at all. Indisputably however portions of Arctic space, land, underground, sea and undersea, are coming to be more significant as what Brenner (2016) calls ‘operational landscapes’, the industrialised non-urban hinterlands that are woven into ‘planetary globalisation’ processes. Brenner argues that such spaces cannot be ‘reducible to a mere backstage ‘ghost acreage’ that supports the putatively front-stage operations of large population centres’ (123). Yet the notion of operational ‘landscape’ risks reducing to a backstage the maritime spaces ‘operationalised in support of city-building processes’ (123).

**Reorientations and disciplinary ports of call**

The research involves a ‘maritime’ reorientation. Despite the prevalence of liquid metaphors (e.g. ‘spaces of flows’ and ‘liquid modernities’), social science has remained mostly landlocked. But watery spaces cover 70% of the planet’s surface, and given contemporary societies’ extraordinary reliance on the oceans for all sorts of transportation, resource extraction and waste disposal functions, are as worthy of social science study as land spaces. The research forms part of a growing body of work on ‘water worlds’ (Anderson, Peters 2013) which seeks to redress the terrestrial biases of social science. Yet the kind of ocean-space at the centre of this research is unusual in that it is partially solid or frozen, or moves with varying degrees of predictability between a solid and liquid state. Sea-ice, the research demonstrates, is a particularly recalcitrant actant that continually thwarts efforts to domesticate Arctic waters and establish reliable surfaces of transportation. Yet this recalcitrance, as with that of the Arctic more generally, is also generative, inducing a range of sociotechnical innovations that attempt to ‘manage’ ice, most notably the constantly evolving ice-breakers and ice-class vessels, as well as increasingly refined abilities to discern the present and future states of ice, including its thickness, extent and location.

This research involves a ‘circumpolar reorientation’ (Craciun 2009), where ‘the Arctic’ (albeit conceived as a dynamic, contested, heterogeneous and varying space), is conceived not as peripheral but as central to ongoing global social processes. Such a a reorientation of the spatial imaginary can be visualised by flipping a model of the globe such that the North Pole rather than the equator comes to sit at the ‘centre’ of the earth. Such a reorientation demonstrates the ‘fluidity’ and multidimensionality of ‘the Earth’ that has come to fascinate geographers and spatially-minded social scientists of late. Centring on the Arctic moreover invites an appreciation the Arctic’s increasing significance to Earth system processes, and also to the region’s emerging geopolitical and geoeconomic significance. In many ways, the Arctic is remote from the urban centres of the world, indeed other than outer space the Arctic stands as shorthand for ‘alien’ environment. Yet Arctic processes exert tremendous gravity over people and places located far from it. The Arctic is always already present and ‘contaminates’ in various ways the lives of people in remote population centres.

A circumpolar reorientation also challenges taken for granted notions of progress and linearity, and invites us to consider the ways circuits and looping mobilities cuts across and recompose territories. 'The loop' argues Bissell 'circumvents points of departure and origin and instead prioritises the passage' (2013: 358). The research also involves a 'mobilities' reorientation (Hannam et al 2006; Cresswell 2006; Adey 2009; Merriman 2013). I employ an expansive concept of 'mobilities' so as to include not only people, objects, information and capital, but also materials such as carbon, water, air and moisture, fish and marine organisms – in other words mobilities not governed or orchestrated by people and organisations – even though such 'natural' mobilities and mobility-systems are increasingly affected by anthropogenic activity.

Examining mobilities in a context where many of the usual taken for granted 'supports' are missing (i.e. the medium of liquid water through which or with which ships are designed to move), forces us to appreciate the role of taken-for-granted non-human forces that make movement and action possible. The Arctic presents an intriguing environment for mobilities research as it is itself 'on the move' in all sorts of ways, not least of which through the volatile mobilities of ice, which advances, retreats, shrinks and reforms in complex yet semi-predictable ways

The case study requires journeying through a number of disciplinary passage points, including science and technology studies, futures studies, transport, economic and political geography, climate science and new materialist philosophy, to name only the busiest ports of call. The aim is to keep moving between, rather than stay docked for too long at any one disciplinary hub, and synthesise into an interdisciplinary mobilities account empirical evidence and theoretical insights generated by these diverse disciplines and approaches. Passage between social scientific disciplines, as well as between the social and natural sciences, is a prerequisite for mapping the emerging entanglements that characterise 21st century globalisation and the Anthropocene.

**Chapter outlines**

The next chapter examines the theories and methodological resources that the research draws on. Emphasised is the enmeshing of human collectives with various non-human forces or ‘elements’, especially routes, resources and wastes. I further explore the three reorientations introduced above, before concluding with a discussion of the mobile methods employed by oceanographers and climate scientists.

Chapter three looks more closely at contemporary ocean space. The oceans serve simultaneously as transportation surfaces, arenas of resource extraction, energy generation, waste depositories and are subject to increasingly complex forms of socio-legal regulation and (dis)organisation. Most fundamentally the ocean is central to the planet’s climate system. I argue that an ‘ocean-turn’ can be seen as resonating across the natural and social sciences. I explore the process of domestication whereby the oceans have progressively been turned from spaces of division to spaces of connection, a process which began in the 1400s with the taking to the high seas, to the of construction of transoceanic canals, to the establishment of the ‘smooth’ system of containerised cargo transportation, arguing that the emergence of circumpolar sea routes marks a new nadir in this process of the domestication of ocean space.

Chapter four examines the contemporary or the ‘anthropocene’ Arctic, before focusing on the NSR. I chart the historical genealogy of ‘the Northern Sea Route’, arguing that there are many ‘northern sea routes’. I trace the development of the route by the Soviet Union and the processes of resource extraction and waste production the NSR was caught-up with. I then move to consider current processes of resource extraction and transportation and the so-called Arctic paradox, whereby melting ice appears to be clearing the way for more extraction and distribution activities. I place the NSR within a shifting 'seascape' of resource extraction and cargo distribution. I examine the operations of a Scandinavian shipping firm that took part in an early journey through the NSR.

The fifth chapter examines more closely the (im)mobilities of Arctic shipping, the way the construction of passages, routes and connections entail many forms of insulation or containment. In order for certain things to move others must be prevented from doing so. In particular, the unruly mobilities of sea-ice must be prevented from impinging on the circulation of ships and cargos. Many forms of insulation are required to safeguard the smooth passage of cargos though a turbulent and shifting environment. Yet many infrastructural absences and discontinuities leave vessels, seafarers and cargos exposed to risks from a hostile environment, and expose a 'delicate' environment to the various seeps and spills associated with shipping activity.

Chapter six documents the variegated processes of contestation over what today has come to be known as the 'Northern Sea Route', starting with early journeys made by Europeans during the Age of Discovery, through to the Soviet Union's 'operationalization' and control of the passage in the 20th century, through to 21st century controversies and contestation fuelled and shaped by rising temperatures, melting ice, and competition for global resources. The battle for control over routes is often caught up with processes of contestation over natural resources such as oil, minerals, fur and spices. However, whilst much attention has been given to subterranean mapping of the seabed and a potential extension of sovereign rights over the outer continental shelf, navigation rights might prove more decisive. I conclude by examining the asymmetric forms of conflict between environmental NGOs and state interests.

Chapter seven examines some of the ways in which a mobile geography, characterised by shifts and surprises, scrambles many taken-for-granted abilities to anticipate the future. The first part of the chapter examines the conditions which combine to make Arctic shipping futures so uncertain or fragile. The second part of the chapter examines a range of efforts to map, model or come to terms with uncertain futures.

## Chapter two: theory and methods

### Introduction

More than half the world's population is now concentrated in cities. These 'colossal banks of humanity' (Serres 1995: 15) are associated with a proliferation of lines linking these concentrations of people and things to distant sources of food, energy, raw materials and manufactures. As human collectives have urbanised so have these 'supply lines' increased in significance for the sustenance of social and economic life – all the while remaining largely invisible to urban dwellers. Routine everyday practices such as filling up at the petrol station, plugging-into the wall, or switching on the heating, involve connections and routes which stretch across land, sea, air, deep-underground and undersea. In particular, urban concentration is associated with corollary processes of expansion through, under and over the world's oceans and seas. Yet this 'ocean space' remains underexplored by social theory, the social sciences and the humanities, although the last few years have witnessed a surge of interest in 'water worlds', particularly in human geography (see especially Anim Addo et al 2014; Anderson, Peters 2014). Shipping remains underexplored, even in the by-now substantial body of literature on infrastructure, from which the thesis found initial inspiration (Bowker and Star 2000; Graham and Marvin 2001; Graham and Thrift 2007; Urry 2007).

This is not just a study 'about' the oceans. This research advances a materialist and 'oceanic' ontology, which emphasises motion, porosity and shifting states (Peters, Steinberg 2015). Emphasised are circuits like the '… looping relations between capitalist production, carbon and methane emissions, state policy, consumption practices, glacier movements, and climate change…' (Connolly 2014: 30). With Coole however I suggest we do not 'pause for too long…' to debate the 'finer philosophical points…' of this materialist sensibility, but 'move on to reckoning of the material circuits… that mark the 21st century' (2013: 453).

A mobile ontology underpins the research. Importantly humans are figured not as sovereigns, but as open to and enmeshed with various non-humans that enable, constrain and condition human action in various ways. Indeed, this very bifurcation with humans on one side and nature on the other is problematic (Latour 1993). Instead we might think of entities or *systems* inhabiting a single plane of existence by dint of their energetic, material and informational openness to one another. I briefly introduce this materialist or 'oceanic' ontology, before discussing three key non-human 'elements' with which people, ideas and institutions are enmeshed, resources, routes and wastes. I discuss the complex intersections between anthropogenic wastes and Earth system processes that are leading to the current Arctic conjecture – the so-called 'Arctic paradox'. I then discuss 'futures' followed by the three key social scientific 'reorientations' the research performs: a maritime reorientation; a circumpolar reorientation and a mobilities reorientation. I conclude with a discussion of methods and their mobilisation to capture a turbulent world-in-motion.

**Materialist ontology**

In a very basic sense, the thesis is concerned with the ways in which volatile Earth processes afford and complicate human action, and the openness of societies, economies and geopolitics to non-human forces. In recent years there has been a sustained attempt to re-think materiality in the field of geopolitics, especially in light of climate change. These approaches reject environmental determinism, wherein states, peoples and societies are figured as determined by natural environments, but rather advocate a 'post-human' geopolitics and international relations theory (see especially Cudworth, Holden 2011; 2013; Dittmer 2013). Here the Earth becomes not just a stage on which human dramas play themselves out, but an actor in the drama, especially as what were implicitly taken to be unchanging characteristics of the Earth now appear much more unstable than previously thought. ‘Geopolitics’ writes Simon Dalby, ‘is no longer about playing the great game of state rivalry; it is also now literally about remaking the playing field’ (Dalby 2009: 4).

The Earth and Earth processes provide the basic material support, or the ‘ground’, for all life; or rather, ‘Earthly’ forces flow through ‘us’. Argues anthropologist Hastrup: ‘the nature in which humans are immersed comprises the elements of air, wind, and water as well as earth’ (Hastrup 2013: 17). Like other ‘infrastructure’, these elements form part of what might be called a ‘material unconscious’, that only become registered at points of disruption or change, most dramatically when they withdraw their support entirely (Clark 2013), or unexpectedly provide new opportunities or affordances. Yet what we all-too reductively call ‘the Earth’ is not static, but fluid and dynamic. Shifting tectonic plates (Massey 2005: 130), the erosion of coastlines by currents, winds, rivers (Maly 2015), the constant movement of silt, sand and soil, the transfer of heat around the planet by winds and currents, or over much slower timescales, the carving of landscapes into forms by the movements of ice (Pollack 2010), demonstrate the *processual* character of the ‘Earth’ . Recognising the Earth’s mutability demands we appreciate its multi-dimensionality, the way processual-space extends upwards and downwards, and the way this affords and complicates human action. In short, it requires us to jettison the ‘Earth’ concept that has come to stand in for the ‘planet’.

As well as ‘Earth’ forces, people are enmeshed with an increasingly tangled and taught web of objects and materials of their own fashioning (Arthur 2010; Hodder 2012), but with their own latent capacities to surprise their creators and alter the course of events (sometimes disastrously), including the ability to seep, hybridise, and become transformed. Modern humans are enwrapped in a mesh of increasing density and viscosity or ‘stickiness’. One does not ordinarily, readily notice this mesh. But at points of disruption or breakdown, it surges into the forefront of consciousness, as experienced by the inhabitants, during Storm Desmond, one of six major storms which hit the UK in late 2015/early 2016 when major floods led to 55, 000 people effectively being left ‘stranded’ by a 3 day power failure, and the unanticipated communications failure that followed

Contemporary patterns of social life presuppose intersecting *systems* like mobile telephony, networked computation, electricity, personal transport and container shipping, all underpinned by particularly profligate patterns of resource extraction. These systems form co-evolving clusters, which exert their own pull over societies and economies.  Contemporary patterns of social life are inextricably enmeshed with physical-digital systems which move people and things around, and are based on intermittent patterns of co-presence. These systems involve many paths facilitating circulations of people, capital, information, objects and resources, connecting and disconnecting people and places (Urry 2007).

We have thus learnt over the last two decades or so to think in terms of sociotechnical, rather than purely social, life. ‘Societies’ might be conceived as meshworks (Delanda 1997; Ingold 2007) of human and non-human ‘elements’. The notion of elements is useful as it connotes a chemical and combinatorial potentiality, as well as the elemental forces, earth, wind, fire which are also permeate societies, which might therefore be thought of as ‘geo-social’ systems or formations (Clark forthcoming). The notion of meshwork is useful as it connotes the entangled character of relations between humans and more-than-human elements, and the tendency for more and more entities to become entangled in this web, like the detritus caught-up in an industrial fishing-net. The mesh of human-fashioned objects, materials and associated wastes is increasingly entangled with Earth processes and the ‘web of life’, producing new often terrifying, hybrids. Humanity – in some form – has infiltrated the soil, the skies, the seas, the ocean-deep. Most significant is the accumulation of $C0_2$ in the atmosphere produced through the burning of fossil fuels in transport, industrial, and domestic systems. Through the mass emission of carbon wastes, Earth system processes are being pushed to thresholds and into states not witnessed for around 10, 000 years. The 'jolt' of climate change forces us to be attentive to the lively or vibrant characteristics of matter (Bennett 2010), its propensity to move and hybridize in surprising ways, with major consequences for what are now globally interconnected societies.

The proliferation of these hybrids is a defining feature of what many scientists propose is a new geologic era, the 'Anthropocene' (Crutzen, 2002). Whether the planet has left the Holocene era remains a question of significant scientific controversy, as does pinpointing a precise date for the inauguration of this supposed new epoch (see debates in Lewis, Maslin 2015). Proposed dates range from the start of the industrial revolution, and the emission of the first carbon into the atmosphere by James Watts' steam engine in 1784, to the detonation of the first nuclear bomb in 1945, to the so-called 'great acceleration' of the 1950s (Steffen et al 2015). Recent work suggests that a fundamental shift occurred following 1492 and the subsequent annexation by Europeans of the Americas, and the establishment of a global network of oceanic trade routes, linking Europe, China, Africa and the Americas (Lightfoot et al 2013; Lewis, Maslin 2015), in other words the inauguration of the modern 'World-System' (Wallerstein 2011). The establishment of these routes led to the unprecedented mixing of previously separated biota, a process of intermingling known as the 'Columbian Exchange' (Crosby 2003). Yet whilst 1492 is figured as a key 'tipping point' in human collectives' relationship with non-human nature, its effects were not registered on the Earth system until more than 100 years later. Lewis and Maslin proffer 1610 as the date when the shifts initiated in 1492 became registered in the planet's geological record. 'The transoceanic movement of species' according to Lewis and Maslin, 'is an unambiguously permanent change to the Earth system' (2015: 177). The latencies and lag between the commencement of events and their becoming sedimented in the geological record demonstrates the difficulties with pinpointing a precise date for the start of the Anthropocene. Furthermore, in geologic time, the difference between the 1750s and 1950s – even the difference between the 1500s and 1950s is vanishingly small. Nevertheless, there is substantial evidence to indicate that the period sometimes designated the 'long sixteenth century' (1450-1640), was crucial in the transformations of human collectives' relationship with non-human nature. Crucially, this period witnessed a qualitative transformation in human engagement with the oceans.

The Anthropocene should not be figured as a collective humanity (which is in actuality only a tiny portion of it) *destroying* nature, as matter can never be destroyed, only transformed. Nor should it be seen as a collective humanity interfering in naturally *harmonious* processes, as rather than poised in balance, nature is dynamic and turbulent. Transformation, including rapid and catastrophic transformation, is fully a part of nature, even without the interventions of people and the incursions of their technical ensembles. Volcanos, abrupt climate shifts, species invasions, extinction events and other catastrophes are fully a part of unfolding evolutionary process. This forces us to reject conceptions of 'nature' figured as benign and poised in 'equilibrium', and recognise the role of positive, as well as negative, feedback processes which can and do push systems into 'far-from-equilibrium' patterns (Gould 2007).

I have introduced an oceanic and materialist ontology, and highlighted the ways in which human collectives are enmeshed with various non-humans.  Central parts of the material unconscious which supports our action and with which we are enmeshed -

but to which we typically remain blind – are routes, resources and wastes, which have all increased in significance especially in the last half century or so, although they pervade all societies – indeed all life. The oceans are vital spaces in this world of routes and circuits, and when viewed over time, form humanity's primary transportation system (Stel 2013.

**Routes**

> No society… can form or sustain itself without paths that link one person to another, that link people and institutions to one another, and that link hominids [humans] to various natural resources. Paths take the form of dirt, gravel, and paved roads, ocean and river shipping lanes, flight paths, mountain passes, train routs [sic], and so on (Bryant 2012; no page).

Paths are one variety of non-human actors which are significant but largely hidden, although often in plain sight. The research draws on and contributes to a body of literature on paths, routes or 'lines' (e.g. Simmel 1994; Clifford 1997; Ingold 2007; Bryant 2012). As Ingold explains, there are many different types of line or path, but a useful distinction can be made between those that are laid out in advance, and those that are improvised or made through movement itself. Ingold details the ways in which 'lines of transport' have come to dominate the world, although in practice these lines involve no small measure of improvisation (Ingold 2004). These lines, like the pipelines that stretch across the world 'form the geographical means in and through which our world is joined together' (Whitehead 2015: 7). Routes are usually unnoticed, forming part of a material unconscious. Once journeys have been made several times they become embodied in *routines*. Routes become registered consciously at times of disruption or innovation. Certain journeys and routes, demonstration voyages, or voyages of 'discovery' and exploration, like those to the North Pole and through the Northwest and Northeast Passages, military parades, exercises, marches, pilgrimages, the re-tracing of historical routes, sports events and heavily mediated convoys like bicycle races, marathons etc., are highly visible and often symbolically laden.

Historian Braudel writes that routes, or what he calls ‘communications’, are the ‘infrastructure of all coherent history’ (Braudel 1995: 282). Braudel describes the Mediterranean in the age of Phillip II as ‘the sum of its routes, land routes and sea routes, routes along the rivers and routes along the coasts, an immense network of regular and causal connections, the life giving blood stream of the Mediterranean region’ (Braudel 1995: 277). Through the carving of paths human (and indeed other animals) domesticate spaces, making them serve, whether through careful and deliberate maintenance or the sheer force of movement, as conduits enabling regular and reliable passage, producing a world that has largely been laid out in advance (Ingold 2004). The notion of ‘paths’ can be seen as both literal and metaphorical, encompassing both physical channels of movement, and enduring arrangements that exert gravity over entities and structure their unfolding in advance, for instance the inherited social systems, institution and ascriptions and identities which shape and produce human individuals (Bryant 2014).

Physical paths are connected to – or anchored in – nodes – towns, cities, mines or other concentrations. An urbanising world has produced both pronounced concentration *and* dispersal of anthropogenic activities, as cities produce supply lines and supply lines produce cities, in a dual process Brenner calls ‘explosion/implosion’ (2014). We might say that routes are ‘anchored’ in the nodes they connect, and nodes anchored in the routes that connect them. Routes not only link pre-existing spaces but bring them into being, or lead to their withering, as when mines become (un)profitable, and towns become (un)viable due to the presence or absence of transport links. Routes link nodes into topological spatial formations, defined by relations rather than proximity. This occurs across a number of scales, from urban tube networks, to national rail systems, to global air and shipping routes. Spaces become unmoored from their immediate surroundings and reinserted into networks, with connectivity supplanting proximity, creating new ‘power-geometries’ which preferentially link certain places whilst bypassing others (Massey 1993; Graham, Marvin 2001)

Routes are relationally *enacted*. Sea lanes and flight paths do not exist on the seas and in the skies for instance but are inscribed onto maps, charts and navigation equipment. Animal migration routes are embodied in animals. The travelling ‘body’ and its capacities help enact routes; for instance pipelines are routes for liquids but not for solids; with new sail technologies, new routes which harness the power of wind-circuits could be created; with fossil fuels new kinds of sea routes become possible, less constrained by wind and current conditions. Ice-breakers, as we shall see, make possible routes through previously impenetrable seas. According to Braudel: ‘There would be no routes if there were not stopping places: a harbour; an open roadstead; a caravanserai or a Han’ (Braudel 1995: 277). Although routes are threshold spaces, of importance primarily for the ways in which they connect other places deemed to be of importance, they tend to attract development across their path, i.e. the build-up of ports or facilities to provide points of rest, repair and security.

Simmel argued that humans are driven by a ‘will-to-connection’, the purest expression of which he identified as the bridge in that it ‘connects the naturally unconnected’ (1994). Yet perhaps the starkest examples of this will-to-connection are manmade canals like Suez and Panama, which facilitate movement though *dividing the already connected*. The opening of the Suez Canal drew distant places into (highly unequal) trade relations, resulting in the transformation of the places linked, for instance facilitating the expansion of European economies. These canals are some of the most dramatic examples of the reshaping of the earth by trade and transport activity. Indeed now humanity – or a small section of it –'…move more than three times as much sediment and rocky material', through activities such as digging tunnels, dredging sea-lanes and widening roads, 'as all the world's rivers, glaciers, wind and rain combined' (Vince 2015: 308).

**Paths and power**

Routes – no less than ideas and institutions – play important roles in the generation, maintenance and disruption of social worlds, and the hierarchies which so often characterise these worlds. It is sometimes asked why the industrial revolution didn't start in China despite being relatively rich in coal, the resource which fuelled industrialisation (see next section). A 'culturalist' account might point to the role of beliefs and ideologies in preventing these transformations. However, geographies and paths are likely to have played significant roles. The coal of China is far from the major cities, and behind difficult to pass mountains and turbulent rivers (Pomeranz 2001; Bryant 2012a: Tyfield 2014). Rather than through disembodied signs, ideologies or institutional arrangements, power is exercised materially – needing conduits through which to travel (Mann 1993), for instance the telegraph systems which stitched colonial empires together (Latour 2005), the fibre optic cable networks that underpin financial power, or the Parisian boulevards and open streets designed to facilitate the swift movements of military vehicles. Militaries and mobilities – or militaries and *speed* are inextricably entangled (Virilio 2006). Argues John Law 'mobility' is the 'first requirement for imperial control' (Law 1997; no page). Armies have since time immemorial constructed 'lines of transport' to support the speedy movement of men and materiel to and from battlefronts. Yet at the same time, the proliferation of such routes fragments the very territorial spatial forms (states) that underpin and motivate geopolitics and military conflict (Johnson, Derrick 2012). Routes simultaneously extend the reach and threaten the integrity of territorial spatial formats. The construction of 'friction-free surfaces across which force can easily be exerted' (Starosielski 2015: 5) has become central to modern, transnational business activity. The search for short-cuts, whether to enhance military reach or accelerate the turnover of goods and capital or both, has been a key feature of the world since at least the 1400s.

Warriors are quick to appreciate the significance of geography and technology. For US naval strategist Alfred Thayer Mahan, writing in the 1800s, controlling the seas was crucial to the exercise of military and economic power. He called this 'sea-power' (Mahan 2014). Land-locked states were at a major disadvantage in the Hobbesian game of interstate competition according to Mahan. By contrast for the founder of geopolitics, Halford Mackinder, controlling what he termed the 'geographical pivot of history', southwest Eurasia, the historic crossroads between East Asia and Western Europe, was central to the 'great game' of geopolitics. In Mackinder's vision the steppes plains and natural resources of this area provided – once overlaid with suitable paths - unique affordances for a central land power to dominate a territory from the coasts of China and south Asia all the way through the Balkans and up to the English Channel. Mackinder viewed the establishment of railroads as amplifying the power of whoever commanded this region (Antrim 2010).

**Lines and Loops**

Routes or paths despite appearances have a *circular* quality to them. One goes back and forth along a route. Routes form circuits. Routes also come and go in circular fashion, leaving traces even when abandoned. Routes appear, disappear and reappear in new forms. Consider the multiple incarnations of the 'silk road'; routes may be developed for one purpose but then become repurposed to support other activities and practices; routes typically emerge, become abandoned, leave traces and then return in altered form (Shelton 2014). Route makers usually follow existing paths and work with the legacies of previous sociotechnical and geologic processes, the 'gifts' of the Earth. As we examine in the next chapter, the oceans provide the most efficacious of transportation affordances, whilst at the same time prove particularly recalcitrant to human path-building endeavours. The oceans simultaneously afford and thwart what Braudel called 'communications' between distant places.

**Routes and turbulence**

According to Cresswell and Martin: 'The production of order in contemporary societies based on circulation is thus not only a matter of fixing things in space … but of channelling motion – of producing correct mobilities through the designation of *routes*' (Cresswell and Martin 2013: 520. Emphasis added). Routes we might say are ways warding off turbulence, and are as much about preventing certain movements as enabling them. Turbulence is a term introduced into the social sciences from the field of fluid dynamics, and refers to 'a chaotic form of motion that is produced when the speed of a fluid exceeds a threshold, relative to the environment it is moving through' (17). In fluid dynamics, 'turbulence is the rule not the exception'. Scholars such as Delanda (1992), Cresswell and Martin (2013) and Starosielski (2015), apply the notion of turbulence to sociotechnical phenomena. Whilst routes provide insulation to movements from external turbulence, at the same time routes themselves are liable to become sources of volatility. Frictional maritime chokepoints like Suez, Malacca and Hormuz funnel traffic into tight streams, increasing vulnerability to disruption. Routes also enable the transfer of entities and materials other than those their designers intend, another significant source of turbulence. For instance, the Suez Canal not only facilitated the movement of goods between Europe and Asia, but the massive transfer of invasive species. Routes therefore can become harnessed for other purposes (e.g. containers for people, drugs and weapons smuggling). Therefore, the production of routes entails the production of new forms of turbulence (Cresswell, Martin 2012), and turbulence or 'friction' leads to the production of new routes. Routes and turbulence are thus reciprocally entwined. Similar to how Graham and Thrift (2009) write on how moments of breakdown are central to making infrastructures more resilient over time, turbulence plays a key role in the evolution of systems, and in the production of new forms of order.

**Logistics**

Routes' role in channelling and preventing deviant mobilities, and conversely preventing 'turbulent ecologies' and circulations from impinging on the smooth flows of freight, is most starkly embodied in *pipelines* and cargo *containers*. As well as finance and resource extraction, contemporary capitalism rests on *logistics*, 'the management of the movement of stuff' (Cowen 2014: 187). No longer relegated to the fringes of the production process, the industry of logistics was predicted to have reached US$3.9 trillion in 2013 (Coe, Hess 2013). Logistics involves what Starosielski calls 'strategies of insulation' (2015) designed to smooth freight flows and minimise uncertainty and the potential for disruption and costly delays. Pipelines and cargo containers (containerisation was modelled on the flow of oil through pipelines) emerged from the desire to insulate energy and cargo mobilities from the turbulence associated with militant dock-workers (Mitchell 2011). As Cowen (2014: chapter 2) explains the pipeline is the favoured metaphor of supply-chain managers as a way of connoting the securitisation of cargo flows from points of production to points of consumption. Argues Starosielski strategies of insulation have 'intensified… as networks have become more critical to our global society' (Starosielski 2015: 19). Military-style supply lines have migrated into business practice, particularly with the commercial appropriation of logistics, supply-chain management and containerisation from the 1950s onwards (Cowen 2014: chapter one). With containerisation and intermodal logistics, manufacturing is outsourced to low wage countries, the global economic map is re-drawn, and new consumer practices based on rapid rates of obsolescence emerge. This reorganisation of the entire system of capitalist production into a 'supply chain capitalism' (Tsing 2012) was (in part) made possible by the creation of new geographies of flexible and virtual container paths (Heins 2013). Containerisation also involves advances in what we might call forms of *routing*, including positioning and tracking technologies (GPS, RFID), real-time inventory, weather and traffic information, which rest on satellite systems and increasingly rapid communications, powerful processing and software modelling. Containerisation attempts to render irrelevant the material specificities of land and sea and construct a 'global surface of logistical integration' which cuts across both (Martin 2013). Containerisation is a fascinating example of the domestication of the Earth by the carving of paths, and is thoroughly dependent on the *resources* of steel and petroleum. Routes are inextricably linked with resources. Routes link concentrations of people or industry to concentrations of natural resources, another kind of non-human with which human collectives are enmeshed.

**Resources**

As Marx long-ago proposed there is a metabolic relation between humans and nature, with humans 'open' to nature and vice versa (Marx 2011). Through natural resources 'nature is converted into society' and both 'nature' and 'society' are recomposed in the process. Such resources include biotic materials such as forests, animals and fossil fuels (that are formed from decayed organic matter), and abiotic matter such as land, fresh water, minerals, metals and ores such as copper, cobalt, aluminium and nickel. Natural resources provide affordances for the construction of the material lifeworlds (sometimes referred to as 'second nature' or the 'built-environment') that envelop biological human organisms. Whilst all life draws on resources, and no human collective could be sustained without resources, the scale and intensity of human resource use has risen dramatically in the post-WW2 period. ‘A defining feature of the Anthropoceneis humanity’s emerging ability to extract, move and exploit resources at geologically significant levels’ (Whitehead 2015: 18). Of central importance are fossil energy resources which provide humanity with ‘a unique endowment of ancient sunlight’ (Hartmann 1998).

**Fossil fuels and societies**

> Fossil fuels made and make us what we are today (Murphy 2007: 211).

Understanding the ways that societies are ‘energized’ is crucial for understanding how they work, with different forms of energy coming to ‘generate’ different types of society (Urry 2013: 1). These energy forms vary, from muscle, wood, wind, water, and solar to coal, gas, oil, hydroelectric, geothermal and nuclear power. Bodies need calories, and machines require fuels to keep them working. Until the eighteenth century energy derived primarily from human and animal muscle power (80-85 per cent), wind, wood for burning and water. Now the burning of the fossil fuels of coal, gas and oil account for over four-fifths of the world’s current energy use (Tyfield, Urry 2014). Ultimately all energy on Earth is derived from the sun. The energies contained within cereals, fossil fuels, wind or water flows, all involve some re-routing, deferral or transduction of solar energy. Fossil fuels extracted today were formed between 200 and 2.5 million years ago, and therefore involve ‘cross-scale subsidies' of ancient solar energy (Carpenter et al 2001: 767). ‘Landscapes of energy extraction are portals, worm-holes’ between the ‘deep-time processes beyond human control that create the hydrocarbon concentrations we know as fossil fuels’ and the ‘social realm’ above (Bridge, Le Billon 2013: 24). Thus, we might say that the current metabolic relationship jumbles spaces and scales, and wherein strangely, the ‘Cretaceous lives again’ (Yusoff 2015: 19).

The energetic efficiency, mobility, and physical forms of fossil fuels enabled the development of modern industry and modern capitalism. Many writers propose that congruence exists between the institutional forms of capitalism and the material properties of fossil fuels, for instance Altvater's (2007) thesis on 'Fossil Capitalism' proposes that the extraction of the surplus energies stored in fossil fuels mirror the surpluses extracted from labour processes (see also Mitchell 2011; Malm 2015). Fossil energies have produced revolutions in manufacturing, mobility, and patterns of habitation. Prior to the eighteenth century, the primary energy source in manufacturing processes was the power harnessed from water flows. Factories thus had to be located close to streams and rivers. According to Marx, Watts' steam engine was: 'entirely under man's control, was mobile and a means of locomotion, was urban and not – like the water wheel – rural, permitted production to be concentrated in towns instead of – like the water wheels – being scattered over the countryside, and finally was of universal technical application, and little affected in its choice of residence by local circumstances' (Marx 2011: 499). Marx was spectacularly wrong regarding the first point! Yet fossil fuels indeed enabled a kind of 'lifting-out' of sociotechnical processes from their immediate environs. Coal liberated ships from winds and currents (Anim-Addo 2011; Gray 2015) and also freed people from dependence on surrounding woodland for heating, meaning they could (or were forced) to congregate and work in the cities where industry was concentrated. An extraordinary spike in population numbers occurred throughout the Western world coincided with the transition to fossil fuels.

Unlike widely dispersed forms of energy like wind, water and wood, fossil fuel reserves (especially oil) are highly unevenly geographically distributed. Thus many people and places became dependent on energy produced by few people at few places. This presented opportunities for control. The financial resources and know-how of large firms, states, and specialist workforces are required in order to reliably extract and deliver fossil fuels to markets (Mitchell 2011). The successful extraction of fossil fuels and especially oil both presupposed and produced concentrations of political, economic and military power. The contemporary world marked by extraordinary disparities in wealth (more pronounced today than ever before in human history) and the concentration of power in the hands of relatively few social actors are indelibly linked to the material affordances and fossil energies. Given the wealth and power generated by fossil fuels and other non-renewable resources, resources are often caught-up in ferocious conflicts and protracted processes of contestation (Klare 2001).

**Oil-dependence**

Whilst the pre -WW2 period was dominated by 'King Coal', beginning around 1930 a mass transition from coal to oil occurred in Europe and especially the US, a transition that would have enormous social, economic and geopolitical consequences (Mitchell 2011; Urry 2012). There were arguably two key events or tipping points crucial in sending societies down oil dependent trajectories and in getting societies 'locked-in' to oil. British Prime Minister Churchill's decision to switch the British navy from coal to oil in 1914 was the first. This gave Royal Navy fleets enhanced speed and manoeuvrability, but entailed dependence on Middle Eastern oil, and the paths through which this oil was transported. The navies of other 'world powers' followed suit, and from then on the acquisition and securing of distant oil supplies became a central strategic objective for states (Kandyoti 2011; Mitchell 2011). Key also was the rise of POL (petrol, oil and lubricants) warfare, during World War Two, which increased the mobility and reach of military forces but also tethered them more tightly to supply-lines (Cowen 2014). Indeed World War Two's massive, industrialised, destructive machine deployed and expressed in a grotesque manner the high level of development of mass industrialisation in the capitalist West as well as the Soviet Union, entrenched more deeply the strategic importance of oil to the modern global political economy' (Labban 2012: 1). Developed through the conduct of the most ‘total’ and industrialised conflict in history were many of the capacities, infrastructures and patterns of resource use that would characterise the period now figured as the ‘great acceleration’ (Steffen et al 2015. Today militaries, especially the US military, are the biggest institutional consumers of oil and other resources (see Nelson 2015 on the Pentagon’s carbon ‘boot print’), and the movement of oil especially be sea is shadowed by military forces, seeking to secure the resources from which they are composed.

The second event was the development of the internal combustion engine, and consequent mass marketing of ‘steel-and-petroleum’ cars, initially in the US. As Bridge and Le Billon argue, the ‘higher energy density of oil changed the economies of scale required for crossing space, allowing the size of vehicle units to fall, from the train and tram to the automobile – and an increase in the power output for a given size or weight of engine’ (Bridge, Le Billon 2013: 9). Motorised transportation became woven into the fabric of life, such that cars went from being a novelty to a necessity for many people and organisations, in much the same way that mobile phones would become a century later. Cars made possible forms of suburban life, which came to prominence first of all across the US, that once in place could only be sustained with cars, and the flows of cheap oil that made car-use viable. Thus, we can say human collectives came to be ‘ensnared’ by fossil fuels (Hodder 2012), as long as we also recognise the importance of powerful interests for whom these partially ‘self-replicating’ fossil-fuelled suburban expansion dynamics provided lucrative opportunities (Owen 2008). Oil has come to be important in many other ways, oozing through the sociomaterial world in unexpected and often difficult to appreciate ways, ‘showing-up in everything from asphalt to milk shakes to drugs to plastics to fertilizers’ (Watts 2012: 439).

According to Labban: ‘Oil became, directly, an agent of globalisation, providing the cheap fuels and raw materials that energised industrialisation and fuelled mass commercial transportation of people and goods across the world, enabling the development of post-war capitalism and the expansion of the world market’ (Labban 2012:1). An oil civilisation or ‘liquid modernity’ (Bauman 2000) developed, with the spreading of cars, trucks, aircraft, oil-fired shipping, diesel-based trains and oil-based heating. In this new initially American civilisation much was newly powered up or now on the move, including people, companies, objects, money, waste (Owen 2011), and oil itself – it’s liquid and lightweight characteristics meaning that it could be transported more easily and traded across the world more profitably. As well as fuelling globalisation, transnational business practices were pioneered by the oil industry. ‘The postwar development of Middle Eastern oil can be viewed as outsourcing of European industrial production’ (Mitchell 2014: 488), and oil companies were ‘amongst the first and largest modern corporations whose operations and subsidiaries spanned the globe’ (Labban 2012: 3), integrating ‘places of production and consumption into a global and uneven network of material linkages’, demonstrating the deep links between the institutional, economic and political aspects of globalisation with its material-energetic underpinnings.

**Carbon capital**

Whilst ‘natural’ resources provide stark examples of the ways in which societies are pervaded, transformed and even ensnared by non-humans, the preceding discussion also demonstrated the ways in which resources are inextricably entangled with ‘social’ dynamics. Indeed, that a given material becomes a ‘resource’ in the first place depends on the organisation of that society. Why oil is produced, where and under what conditions, depends on a range of considerations. The politics and economics built around fossil fuel systems are of central importance. Questions regarding who ‘owns’ and profits from resource wealth are paramount. The actors who organise, manage and profit from the production, distribution and consumption of fossil fuels, we can call ‘carbon capital’ (Urry 2011; 2013), and we might say they attempt to ‘surf the waves’ of sociotechnical processes of fossil fuel dependence, so as to maximise opportunities for the realisation of profit. Patterns of ownership vary globally, with many complexities regarding who owns reserves, and the ‘rights’ to explore and develop reserves, but most involve hybrids of ‘state’ and ‘private’ actors, hybrids produced through the process of fossil fuel extraction itself (consider the rise of so-called ‘petro-states’ which seek ‘rents’ from foreign oil companies). Important for this research are the political economies of oil and gas – as well as other resources – in Russia (Labban 2010; Bouzarovski, Bassin 2011; Gustafson 2012; Bradshaw 2013), and the specific dynamics surrounding resource extraction and transportation in the Russian Arctic. Russia produces some 12 per cent of global oil output (IEA 2013). A recent trend in many petroleum holding states is ‘resource nationalism’, whereby states refuse to allow participation of the world’s (Western) major oil companies (a good example is Venezuela). This poses problems as in order to maintain profitability, energy companies must have new sources come on-stream before existing reserves run dry.

Energy companies must constantly find new sources of energy to remain profitable. According to Dicken: ‘This is not unlike searching for needles in haystacks’ (2011: 254). This takes time, requires large capital, and involves ever more sophisticated technologies of geochemical and satellite remote sensing. ‘The situation is not unlike other fields like the pharmaceuticals industry, whereby vast investments are made over many years in the hope that a drug breakthrough will occur. In fact of course, the majority fail, and that is also true of the extractive industries’ (Dicken 2011: 254). This anticipatory process, whereby reserves are sought in advance drive the global economies of oil rather than response to some pre-given demand (Dicken 2011: chapter 8).

Price movements invisibly orchestrate the geographies of resource extraction, which shift in relation to one another, as some reserves and potential reserves become more or less profitable depending on events occurring far-away. For instance, when oil prices rise, the Canadian 'Tar Sands' are brought on-stream. Thus, we can say the 'energy frontier' shifts and these shifts are 'modulated by the global political economy of oil' (Johnson 2010: 840) – that is to say, the relative cost of oil from other sources, which reflect a range of 'above ground' considerations (Downey 2009). Price movements may not even be tied to physical production but to 'events' taking place in the relatively autonomous realm of finance (Labban 2010). Financial speculation plays a significant role in oil price swings, and the price of oil tends to fluctuate erratically. Price volatility is a central characteristic of the political economies of resources, especially oil.

In recent years, hydrocarbon *gas* has come to play a more prominent role in the global energy mix, especially in domestic heating and cooking. Hydrocarbon gases include shale gas – essentially 'undercooked oil' – of which there has been a large increase in the production of especially in the US in the last few years. Another form is gas that is liquefied for transportation, In the Russian Federation, key carbon capitalist actor Gazprom sold approximately 250 billion cubic metres of natural gas in 2008. In 2013 the Group produced 487.4 billion cubic meters of natural and associated gas. Gazprom supplied Europe with 161.5 billion cubic meters of gas in 2013. Other resources that have come to be indispensable to the contemporary built-environment are metals, like iron ore, nickel and aluminium. Iron ores are rocks and minerals from which metallic iron can be extracted. Iron ore is the main ingredient in steel, which is used in the construction of ships, automobiles, and industrial structures. Nickel is another important metal also used in the production of steel and other industrial, commercial, and consumer goods. Aluminium is utilized in a broad range of domestic, industrial and military technologies, its strength and lightness ideal for planes. Argues Sheller, 'aluminum is a substance constitutive of modern mobility due to the crucial part it plays in the transportation, construction, and the aviation industries. It also moves our electricity, without which many other things would not be able to move' (Sheller, 2014: 10).

**Resource and energy routes**

Because the geological conditions for the formation of many of the materials that have become 'resources' for contemporary societies are not found everywhere, resources – such as crude oil – are highly unevenly distributed around the world (Bridge, Le Billon 2013). These imbalances between areas of production and consumption are the very basis for the global trade in oil. Another consideration that affects the relative profitability of resources is the existence or not of viable *paths* linking them to markets. Whilst all industries face problems in getting their product to markets, 'the particular characteristics of the extractive industries – especially their bulk and remoteness from markets – generate the need for a massive scale of transportation infrastructure that is virtually unique' (Dicken 2011: 255). Thus, mobilities and paths are central to resource extraction. Resources travel across continents by ships. Shipping capacity, the existence of viable sea lanes and other transportation considerations also affect the relative profitability of resources from particular locations.

Thus, even as fossil fuels, and the forms of movement and communications they enable, seemingly produce 'the annihilation of space by time', space and fixed location continue to matter, have arguably never been more important, with specific sections of the Middle East, oil fields like Gawar in Saudi Arabia, maritime chokepoints like the Straits of Hormuz, and now perhaps sections of the Arctic, of the utmost strategic significance. The Persian Gulf is not only a major repository of oil, but it is relatively close to major markets, with Europe, India and China all within two weeks of tanker travel or less than 6, 000 km of pipelines. As well as the Middle East, other parts of the world which hold significant reserves of oil include North and West Africa (especially Nigeria), Latin America, Russia, Azerbaijan, and the Arctic. This point about the significance of specific sites in a globalised world extends to other key nodes like transportation hubs, server farms and data centres (Harding 2015). The globalised world is one of simultaneous concentration *and* dispersal that mirrors the chokepoint geography of fossil fuels.

The scale and intensity of natural resource use has intensified dramatically in the last half a century or so, and so the paths through which (especially energy) resources move, have come to take on especial strategic significance. The focus of state 'energy security' initiatives has today shifted away from protecting reserves to securing the routes through which energy moves (French, Chambers 2010). Militaries putatively engage in operations to secure states' national economic interests, but militaries are themselves major consumers of oil and other resources, especially primary metals like nickel and aluminium (Sheller 2015: 8). The movement of energy resources, particularly in tankers across the seas is shadowed by military mobilities, and haunted by the threat of military violence. In another example of the 'loopy' character of the processes I document, fossil fuel resources, especially oil, have come to prominence because of their centrality to the 'lines of transport' and systems of movement that now straddle the world's land, sea and air spaces. Energy resources that took hundreds of millions of years to form have been burned in just a few hundred years. The mass burning of fossil fuels produces wastes, in the form of greenhouse gas emissions. The carbon materials emitted can be considered lively, agentive.

**Wastes**

When we follow paths back to the source of all materials and manufactured objects found in modern cities, we arrive at places like forests, natural bodies of water or the 'scattered geography of holes' (Bridge 2010) from which fossil fuels, minerals and metals are extracted. When we follow paths forward, we arrive at garbage dumps, and other accumulations of wastes, like the Pacific Ocean 'plastic gyre', or indeed atmospheric greenhouse gas (GHG) accumulations (Song 2013). The disposal of things does not of course mean that they 'go away', especially today when many of the materials in circulation do not decompose but accumulate, hybridise and become transformed, often in extremely hazardous ways. According to Beck (1992) invisible and inexperience-able risks define our very modernity. Wastes tend to accumulate and cause problems 'downstream' or in the future. In capitalist production processes wastes are figured as 'externalities', outside the production process proper, the financial and other burdens they create passed on or 'externalised'. The 'just-in-time' practices which have come to reorganise capitalist processes discussed briefly above, configure immobility as 'waste', and so to be zealously avoided. Ironically this system is associated with the production of material wastes on an unprecedented scale. The waste output of societies is projected to double in the next 20 years (Davies 2011). Wastes might be said to encompass solid garbage (i.e. discarded electronics parts), liquid garbage (i.e. waste waters) and gaseous wastes (i.e. carbon dioxide, nitrous oxide, soot etc.). Particularly significant are wastes' 'atomic mobility' (Davies 2011). For instance plastics break down into micro particles and seep into wider ecologies (Gabrys 2009). Plastics have formed vast, spinning oceanic garbage dumps, made up of discarded items like bags, wrappers, bottles, toys, toothbrushes and shoes. 'The recognition that these banal objects, intended for momentary human use, pollute for eternity renders them surreally malevolent' (Alaimo 2012: 487).

Paradoxically plastic made possible new forms of insulation, preventing household liquids and wastes from seeping, yet plastics themselves seep dangerously into ocean waters, entering and circulating through biological ecologies. Microplastic particles are now virtually ubiquitous in waterways and oceans, and will likely leave identifiable fossil records for future generations to discover (Waters et al 2016). However, 'the output of waste generated by modern industry is so massive it can render even a benign substance such as carbon dioxide toxic' (Sassen 2015: 155).

Psychoanalyst John Keene offers an explanation for why humans refuse to stop polluting the planet. In infancy, children discharge waste matter without limits, and learn that the caring mother will clean up. As a result of these repeated encounters, human beings become accustomed spoiling their surroundings, believing that the planet is an unlimited 'toilet-mother' (Keene 2013). Michel Serres (2011) makes the link between despoiling the environment and the marking of territory. Serres (2011) argues that humans mark their territories – much like other animals – through wastes. However, as humans are technologically extended and articulated, these wastes involve the production of more than just biological matter, but materials such as soot and $C0_2$, the waste products generated through mechanical processes of metabolism. Jason Moore argues that much as modern capitalism 'encloses the atmosphere as a gigantic dumping ground for greenhouse gases' (2015: 29).

**Wastes and climate change processes**

Any intake of energy produces associated waste outputs. Wastes which result from burning fossil fuels in transport and industrial activity have had the most dramatic consequences for the planet. Central to this has been the rise of the system of automobility. Ironically, part of the appeal for the transition to 'horseless-carriages' that took place in many cities throughout Europe and especially America during the early 1900s was that cars, unlike horses produced less visible and odious wastes.

Immobile solid wastes were replaced by highly mobile gases that dispersed into the air, even if smoke initially also stained surrounding air. Through exploiting the spatial and temporal gaps between events of combustion and their registered effects the problem of accumulating wastes could be deferred into the future (See Clark, Yusoff 2014 on 'combustion and society'). Yet the effects of long-lived GHGs emitted in the process of combustion are far more complex than the effects of solid biological wastes. Indeed we might say there is a globalisation of wastes; 'globalisation is more than telecommunications and an integrated worldwide economy. Earth's atmosphere has always been globalised – when we deliver climate-changing greenhouse gases to the atmosphere in the Northern Hemisphere it is not long before the effects of atmospheric pollution are communicated to the rest of the world' (Pollack 2010: 34).

$C0_2$ remains trapped in the atmosphere for hundreds or thousands of years. Prior to the industrial revolution, global concentrations of carbon dioxide ($CO_2$) in the atmosphere had fluctuated closely around 280 parts per million (ppm) for several thousand years, but exceeded 500 parts per million in 2013. Even if emissions were to stop today there is some inevitable warming 'already in the pipeline' (Hansen 2008: 8). Climate change can be seen as a problem resulting from the accumulation of gaseous wastes (Song 2013). The climate system is an open system, made up of looping intersections between the atmosphere, hydrosphere, biosphere and geosphere. 'Forcing factors' like GHGs can push climate processes beyond current thresholds, and 'create changes on scales from long-term and transitional to short-term and sudden' (Bridgman, Oliver 2014: 1). Indeed, the division between climate and weather is becoming increasingly blurred, with local weather events often today discussed within the context of a changing climate (for instance the storm and flooding events that rocked the north of England in late 2015).

The climate system is highly non-linear, meaning effects can be disproportionate to causes (i.e. due to ‘snowballing’ effects small changes can have big effects), there are latencies and delays, and the consequences of actions may not be felt until long after these actions are initiated (Bridgman, Oliver 2014). The Earth’s climate system includes large, ready positive feedbacks provided especially by parts of the cryosphere – the world’s snow and ice regions – Arctic sea-ice, the West Antarctic ice sheet, and much of Greenland’s ice (Hansen 2009: 9). These are constitutively fragile ‘tipping elements’ (Lenton et al 2008), whose collapse could precipitate an irreversible transition to new states.

As Johnson argues: ‘Following the ‘further adventures' of carbon by-products raises theoretical questions about causality and the spatial and temporal scales at which environmental waste generates problems’ or indeed as we shall see in relation to the Arctic, ‘*opportunities* for the conditions of production’ (Johnson 2010: 833. Emphasis added). Wastes are commonly conceived as undermining conditions for further production activities. However, what is being called the ‘Arctic paradox’, involving feedback loops whereby carbon emissions lead to ice-loss which (supposedly) makes Arctic hydrocarbons and shipping routes more accessible, demonstrates a different relationship between production and waste processes, what Johnson calls ‘accumulation through degradation’, where ‘through a remarkable intersection of capitalism's historical development, biogeochemical processes, and the climate system's physical dynamics, the original externalities of GHG emissions themselves… do physical work’ (Johnson 2010: 834). Thus, wastes can no longer be considered externalities, as they bizarrely feed back into production cycles, providing new extraction/production and transportation affordances. ‘Within this iterative cycle of accumulation by degradation, fossil energy and its wastes may both operate as subsidies for capital’ (Johnson 2010). States and carbon capitalist interests are positioning themselves in *anticipation* of increased accessibility of Arctic resources and routes.

**Futures**

Open systems entail uncertain futures (a sample of the burgeoning literature on ‘futures’ includes Adam, Groves, 2007; Anderson 2010; Tutton 2012; Urry 2016). We live in an era of astounding material complexification, for instance spaces are interconnected and material objects contain other objects and so on ad infinitum. Yet these entanglements are also temporal, such that previous histories and events are folded into the present. For instance, the system of automobility not only entails spatial networks that link together resources from one part of the globe to petrol stations and cars on the other. The entanglement is also temporal, involving the invention of the wheel tens of thousands of years ago, as well as the ‘cross-scale subsidy’ of ancient solar energy provided by fossil fuels. We might say that developments are always moored or ‘anchored’ in previous developments, which provide the conditions of possibility for what follows. To understand a system, process of event, it is therefore necessary to understand its history. There are thus routes or wormholes connecting the present with the distant past as much as there are routes connecting geographically distant places. The past continues to inhere in the present partly as humans pass down and preserve technologies, practices, languages and customs (Steigler 1998). It is also to do with the longevity of objects and materials. An object like a building typically outlasts many human lifetimes, and provides a sense of historical continuity. The kinds of materials that began to emerge in the 20th century, radioactive isotopes, and greenhouse gases for instance can last thousands of years. This means that, for instance, the consequences of people driving their cars today will reach far into the future.

So, action underway now casts shadows over the future, yet at the same time futures become more difficult to predict, given the inherent uncertainties regarding how long-lasting and volatile materials might intersect with each other, with Earth processes, and with as yet unknown sociotechnical processes. The accumulation of materials, and their combinatorial potentials, makes surprises likely. We know our actions will come back to haunt 'us' at some point as events are 'remembered', but how, exactly when, and with what consequences remains unknown (Adam, Groves 2007). Non-linearities, runaway feedbacks and cascading consequences pose major challenges for efforts to discern futures in detail. Knowing a system's past is key to modelling its future. But analysis of past trends is only of limited use in a world of surprises or emergence.  As Bryant explains we tend to think that the 'being' of entities is 'exhausted by how they are given here and now' (2015: 292). Yet material 'things are characterised by a sort of mysteriousness harbouring hidden powers that hold themselves in reserve, waiting to erupt under the right circumstance when they enter into the appropriate interactions with other things' (2015: 293). This recognition should foster a sensibility of 'humility and caution' (2015: 293. See also Latour 2008).

Yet efforts to model, predict and indeed *act in advance* of futures have proliferated in recent times along with this uncertainty. The media, academia, business and security apparatuses are sensitive to the faintest of signals of impending change. New forms of 'seeing in advance' can be discerned across media (Gruisin 2009), business, traffic management, emergency response and security (Anderson 2010), insurance, weather forecasting, climate modelling, and medicine and genomics (Tutton 2012). These anticipatory techniques are underpinned by increasingly powerful computational hardware, processing capacities, and increased granularity of representation, making possible the harvesting and analyses of vast quantities of data, in theory leading to unprecedented abilities to predict futures. Of central importance are General Circulation Models (GCMs), numerical models used both in weather forecasting and climate change modelling. These models have grown ever-more powerful and operate at increasingly fine grained scales of observation. That global average temperature is rising, that ice will melt, and that sea levels will rise is now beyond reasonable doubt (IPCC 2007; 2014). However, the precise ways in which Earth system elements, particularly the oceans and ice-sheets, will respond to temperature rises remains uncertain. Paradoxically, in many ways as knowledge of these elements increases so does uncertainty. ‘The more knowledge the less certainty’ as climate scientist Trenberth puts it (2010).

Charting emerging trends and possible futures is a contemporary cultural fascination – indeed one in which this research partakes. The modest increases in traffic along the NSR ‘could be the start of something big’ in the words of a 2014 BBC report on the Northern Sea Route. In other words, they could be signs of an impending ‘tipping point’. The establishment of a sea route around the Cape of Good Hope in the 1400s, turned out to be a tipping point which led to a redrawing of the global political and economic map, ushering-in the period of European dominance, and the beginnings of the modern-day ‘World-System’. The link between shifting trade routes and shifts in the balance of geopolitical and geoeconomic power is part of the heightened sense of anticipation that surrounds Arctic sea routes. Yet tipping points can only become known retrospectively; there is no way of knowing whether traffic increases along the NSR are early signals of an impending tipping point as momentous as the carving of a route around the Cape of Good Hope, or whether these modest increases are just ‘noise’ or random fluctuations.

The proliferation of techniques for 'seeing in advance' can also produce further uncertainty, as knowledge of the future can have performative and counter-performative effects. Indeed, the point of modelling climate futures is to effect changes in the present. The present is packed with potential. There are many possible futures already in the making (Adam 2010), but some are more likely than others. As Urry and Woodhead write it is necessary 'to overcome the Scylla of determinism and the Charybdis of complete openness to possible futures' (Urry, Woodhead 2015: 4).

I have introduced a materialist, ocean ontology, and outlined the openness of human collectives to non-human forces, and emphasised the role of resources, routes and wastes, and the uncertain futures that open systems portend. I now introduce the three main reorientations performed by the research.

**Maritime reorientation**

> The oceans and seas are entwined, often invisibly but nonetheless importantly, with our everyday lives. Trade, tourism, migration, terrorism, and resource exploitation all happen in, at and across the oceans. The globalised world of the twenty first century is thus thoroughly dependent on water worlds (Anderson, Peters 2014: 4).

The thesis draws on and aims to contribute to a broader 'maritime reorientation' in the social sciences, which centres previously marginal ocean processes, and highlights the significance of the oceans to industrial societies which, paradoxically, have become 'sea-blind' (George 2013; Steinberg 2015). Across the physical and social sciences there is increasing recognition of the ocean's centrality, both to human globalisation and to Earth system processes. The oceans are a key part of the material unconscious (in psychoanalysis the oceans are sometimes mobilised as a metaphor for the human unconscious), the enveloping skein of natural forces, infrastructures, objects and materials that invisibly support social worlds and lives. Even deeper linkages bind terrestrial humans to the seas than the processes detailed by Anderson and Peters above. The origins of all life on earth are aquatic. ‘The sea surges through the bodies of all terrestrial animals’, Alaimo reminds us (2012: 482). Roughly half the oxygen we breathe is produced by ocean-dwelling plankton, and our eyes are surrounded by salt-water not unlike the ocean, giving a particular irony to George’s notion of ‘sea-blindness’. In short, the ocean envelops us (Carson 2002).

Social science has remained a largely land-locked discipline, overwhelmingly concerned with terrestrial processes. Yet globalisation is a fundamentally maritime phenomenon, as it has been since its inception, which following World Systems theorist Wallerstein (2011), we can say was initiated during the ‘long 16$^{th}$ century’ (1450-1640), and especially by the voyages of ‘discovery’ and the establishment of sea routes to Asia and the Americas. Since then what modern scientists call the ‘World-Ocean’ has become even more significant to global social processes. The oceans are the primary distribution spaces of ‘supply chain capitalism’ (Tsing 2012; Chua 2015), as they are the key transit spaces across which moves the fossil energies which fuel industrial societies, and an estimated 90% of the objects that form part of the fabric of urban social life are moved across the oceans (George 2013). Yet the watery spaces and routes ‘in-between’ states have received little attention until now. This replicates logistics’ tendency to treat the oceans (and indeed all space) as frictionless ‘surface’, without distinctive characteristics. The geopolitical and geoeconomic rise of China has been enormously consequential as its economy is dependent on the oceans both for exporting manufactures and importing resources (French, Chambers 2010). The oceans also play increasingly important resource extraction (especially oil, gas, fish and minerals) and energy production functions (especially wind farms), and have become unexpected repositories of wastes, including plastics and most crucially carbon wastes. The oceans play what is now coming to be recognised as the decisive role in the Earth's climate system (Broecker 2012).

Despite their utter significance the oceans are designated as a nothing other than a 'backdrop to the stage on which the real action is seen to take place - that is the land – or… simply as the means of connection between activities taking place at coasts and in their interiors' (Mack 2011). The oceans cover 70% of 'Earth's surface. The concept of 'Earth' originates with medieval peasants for whom the oceans played little visible role in their lives. 'So they named their environment 'Earth', which is derived from the Anglo-Saxon word Erda… meaning ground or soil' (Stel 2013: 194). More recently the oceans have receded from popular consciousness partly as the visible interfaces between land and sea have moved from urban centres to urban peripheries in order to handle the extraordinary volumes of freight the system of containerisation has made possible (discussed further in chapter three), partly as the oceans are implicitly regarded as purely 'natural' spaces (the sea is a 'quintessential wilderness' according to Mack (2011: 7)), and thus of little interest to social scientists, and partly as these liquid spaces make sedentary habitation all-but impossible (libertarian experiments in 'sea-steading' notwithstanding. See Steinberg 2011). But as geographer Steinberg has long-maintained, the oceans are 'spaces of society' rather than merely 'used by societies' (Steinberg 2001).

A notable exception to the 'sea-blindness' of the social sciences was Braudel's classic work on the 'vast, complex expanse' of the Mediterranean, which he conceived as a lively, multiplicitous space across which people travelled, fished, fought wars, and drowned (Braudel 1995). It was the Mediterranean Sea itself that was centred in his analysis, the entire region defined in relation to the sea that connected it. As we see later the Arctic is being characterised as a 'new Mediterranean' (Steinberg 2014). Braudel's work is also highly pertinent to this study in that he explicitly recognised and sought to account for non-human agencies, particularly geographical agencies, in shaping socio-historical processes. Braudel demonstrates the ways in which the carving of ocean routes, and the ways the unique geophysical characteristics of specific seas and channels, both enabled and thwarted the carving of routes, with important consequences for the social and spatial organisation of life on land (Braudel 1995). Geography is the 'writing of the earth'; the seas cannot be inscribed upon in the same way as land, although as we shall see, particularly in the next chapter, the oceans are stained in all sorts of ways by anthropogenic activities. Yet this research makes clear that particular ocean spaces have a history.

Whilst much 21st century social science and humanities work on the oceans emphasised the ocean's 'social' character, more recent work has emphasised the distinctly fluid and dynamic materialities of ocean spaces, that are 'characterized by complex movements and interdependencies of water molecules, minerals and non-human biota as well as humans and their ships' (Steinberg 2013: 159). Ocean-spaces are the ultimate mobile geographies, turning in rhythmic, often turbulent undulations, but also changing state, existing as liquid water, ice and vapour. The often-unpredictable shifts between the oceans' solid and liquid states are a key theme for the thesis. The oceans are also 'fluid' in that they are three-dimensional spaces, which afford movement not only across but downwards and upwards. 'The character of the sea', argue Steinberg and Peters, 'its vertical depth, together… with its movement, its horizontal surface, its angled waves—is a space not moved on, but through' (Peters, Steinberg 2015: 8). The concept of 'ocean-space' (Stel 2013) designates the enmeshing of marine environments with anthropogenic activities, and the positive and negative feedbacks that characterise these relations. The ocean precedes humans by some 4 billion years. Ocean space is central to climate regulation, the hydrological and carbon cycles as well as nutrient flows, it balances levels of atmospheric gases. But humanity has also domesticated ocean space; it is humanity's primary transportation medium, a major source of resources, a sink for anthropogenic pollutants, and enmeshed with ideas, legal systems and practices of 'zoning'. 21st century ocean space also comprises ocean-observing satellite surveillance systems and fleets of robots providing continuous data on the present and future state of ocean-space. Indeed, the increasing attention to ocean processes discernible across the social and natural sciences, is predicated on the new forms of 'vision' made possible by satellite imagery, which it may be argued have produced a new 'optical unconscious' (Benjamin 1994). The ability to observe the planet from space challenges land-centric biases; the planet viewed from outer space is more 'water world' than 'Earth' (Stel 2013: 194). Numerous marine biologists and author Arthur C. Clarke have extended this claim by noting that "earth is a misnomer; the name of this planet should be Ocean" (Clarke, cited Mentz 2015: no page).

**Circumpolar reorientation**

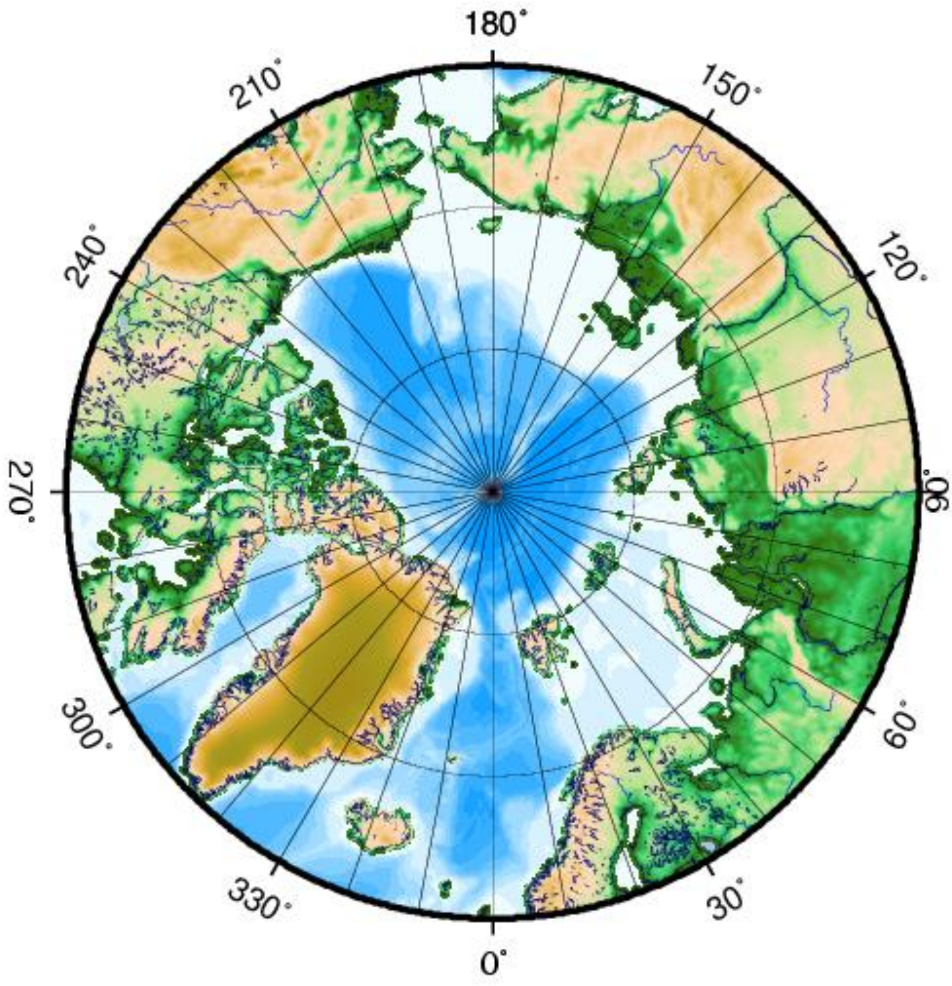


Figure 2.0. Circumpolar map of the world. Source: Wikimedia Commons https://commons.wikimedia.org/wiki/File:World_map_part_Arctic.png

The second shift performed by the research is what Craciun (2009) calls a 'circumpolar reorientation'. Such a reorientation aims to 'reorient the… imagination… along a different imaginary line – not the equator but the Arctic Circle' (Craciun 2009: 104). This can be imagined by 'flipping' the globe so that the North Pole is centred, a perspective no more arbitrary than centring the meridian or Equator (figure 2.0). This enables us to apprehend that the 'Arctic is not an uninhabited, timeless wasteland found on the fringes of the planet- it inhabits a centre' (Craciun 2009: 103). This call comes with the growing recognition of the Arctic's significance, indeed its increasing significance, within both globalisation and Earth System processes. A view of the world centred on the North Pole, owes much to the political activities of *Inuit*, the indigenous group now concentrated predominantly in the Canadian Arctic, but who emerged originally from eastern Siberia, travelling through Russia, Greenland and Canada, ‘long before any such nations existed’ (Anderson 2009: 9). Through the establishment of the Circumpolar Council in the late 1970s, an organisation set-up to represent all indigenous peoples of the Arctic regardless of which of the 8 ‘Arctic states’ (Russia, Canada, Denmark/Greenland, Norway, USA, Finland, Iceland and Sweden) they found themselves in, Inuit ‘were the first to make us see the way the top of the world was interconnected’ (Anderson 2009: 9).

> Only quite recently have people begun to see the Arctic as a region in its own right. Over the centuries, it has been a last frontier for explorers racing to the North Pole or searching for a new trade routes... It has been a source of quick wealth for adventurers taking its whale oils, walrus ivory, fox furs, and bear skins. It has been a cold war border, rimmed by the defensive early warning radars of the United States and the Soviet Union, criss-crossed by the secret trails of submarines hiding under the ice... (Anderson 2009: 8)

Craciun argues that: ‘The circumpolar is central to any notion of the planetary because it is not ‘just’ a region, continent, an ocean, a hemisphere, a direction… it is… a reorientation of the whole world’ (2009: 103). Arctic climate change is having ripple effects throughout Eurasia in climate, society and ecology (Kelmelis 2011) making it important to view regions in relation to one another rather than in isolation. Yet the specificities and ‘remoteness’ of the Arctic are as significant as the Arctic’s geopolitical, geoeconomic and geophysical entanglements with the rest of the world.

The Arctic is predominantly a maritime space. Yet as a partially frozen maritime space it evinces a paradox, and challenges the ‘ideologies of land and sea’ (Connery 2001) that are central to the notion of the international. An argument that returns throughout the thesis is that the state-system is based on a binary where land is seen as state territory and sea as international However, sea-ice undoes this binary (Gerhardt et al 2010; Steinberg et al 2015), as it has qualities of both land and sea, solid and liquid but is reducible to neither. ‘Simultaneously fluid and solid, turbulent and rigid (but rarely tranquil) the Frozen Ocean posed unique problems for ideologies of ‘land and sea’ (Craciun 2010: 694). This liminality produces problems: ‘Because of the Frozen Ocean’s exceptionalism, elemental ideologies of oceanic fluidity became obstacles to the Europeans charged with traversing these icy seas like any other oceanic space’ (Craciun 2010: 694). Indeed, border and boundary drawing practices and the way the Earth’s and particularly Arctic oceans’ fluidity complicates such practices are a key theme of the thesis.

Focus on the Arctic allows us to reconceive globalisation, in a way which much more explicitly recognises the differences made by non-human forces. The ‘Arctic invites us beyond the terrestrial ‘global human’ ideal on which current ‘planetary longings’ typically depend, offering allegiances with non-anthropocentric alterity on an extreme scale’ (Craciun 2009: 113). A ‘circumpolar reorientation’ disables the logic of teleological progress itself. A circumpolar reorientation invites a shift from lines to loops. As ships make their way across the Arctic passages, they follow not straight lines but loops. Indeed, the trope of loops is especially apposite, as the search for Arctic passages, and ‘new’ routes to Asia, evinces a kind of ‘cycling back’, history repeating itself. As Craciun argues: ‘we are participants in the newest turn in the struggle to make the Arctic conform to temperate tropical models, as diverse, national, transnational and indigenous groups stake their claims in new disputes made possible by the Arctic’s increasing fluidity’ (Craciun 2010: 694).

Centralising the Arctic means sustained engagement with the *ice* that is its defining feature. Ice is a most versatile and paradoxical of substances. It is both the most obdurate of substances, the ultimate archive (through which amongst other things knowledge of past climate can be read) and the most fleeting and ephemeral of materials. Ice writes Pollack:

> … can flow downward like a river, carve rock like a chisel, reflect sunlight like a mirror, and float on water like a cork. On a human scale it is a platform for wintertime fisherman, an arena for combative hockey players, a stage for graceful skaters, and an integral component of scotch on the rocks (Pollack 2009: 35)

Like the oceans ice has been on Earth much longer than people have. Ice is a landscape sculptor and key player in the Earth's climate system. Yet ice has been domesticated we might say in various ways, as the quote above hints at. The use of ice in practices of refrigeration has enabled consumer practices which transcend to some extent the seasons; yet it is precisely the presence of ice that makes seasonal shifts so significant for life in the 'High North'. The rise of industrial society has brought the relationship between ice and humankind to a precarious 'tipping point'.

Today human activities are having a profound effect on Earth's climate and destabilising the world's ice. Because temperatures oscillate about the freezing point over much of the planet, its snow and ice regions known as the *cryosphere*, is particularly sensitive to changes in global mean temperature. In a tight coupling that represents one of the strongest feedback systems on the planet, global climate is also directly affected by the state of the cryosphere. Earth temperatures are primarily governed by the net radiation that is available from the Sun. Snow and ice cover influences the ‘energy budget’ of the planet, fluxes of heat and moisture between the atmosphere and surface and the pattern of circulation in the ocean and atmosphere. ‘Each element of the global cryosphere interacts with and affects weather, climate, and society, and each is highly sensitive to global climate change’ (Marshall 2012: 8). Of particular significance is the global albedo – basically planetary reflectivity – which is heavily influenced by the aerial extent of snow and ice covering the planet. Although the polar ice caps make up less than one tenth of the Earth’s surface, they account for much of the sunshine reflected from the surface. The ice-caps therefore have a significance which is disproportionate to their size or area. Polar ice also generates huge wind streams that spill off the ice-caps and flow far beyond the perimeter of the ice to affect global weather patterns. Attention to the oceans, the Arctic, and global weather patterns reveals a world of global linkages and mobilities.

**Mobilities reorientation**

Recently a ‘mobilities paradigm’ has emerged, which foreground the many intersecting, movements which come together to produce and pattern social and economic life (Sheller, Hannam and Urry 2006; Urry 2007; Cresswell 2010; Adey 2010). This new ‘paradigm’ ‘emphasises the dynamic constitution of all social relationships through the mediation of distance and the growth of interconnectedness’ (Vannini et al 2009: 122). The mobilities paradigm ‘brings to the fore and enacts theories, methods and exemplars of research that so far have been mostly out of sight’ (Büscher et al 2011: 4). As such it provides a promising theoretical basis for research on shipping and the seas, especially as the interdisciplinary field of mobilities research challenges the ‘sedentarism’ of social science (Urry 2007: chapter 2). Mobilities challenges the primacy granted to face-to-face social relations in social science, as relations are now mediated by systems of movement and communications. Traditional social science had a tendency to ‘privilege roots over routes’ (Vannini et al 2009:

122). In focusing on routes, on the in-between and on the way, the work is a contribution to mobilities research.

I propose to extend mobilities approaches in a few ways, into a mobile, 'ocean' ontology which examines the intersections not only between sociotechnical systems, but also the way the latter intersect with Earth system processes and circulations, treating ocean and wind circulations, animal migrations, trade and transport activity as forming complex relation patterns of movement and existing on the same plane of being (Vannini et al 2009: 122). Indeed, the case study involves a moving background, of mobile ice-floes, changing ice-conditions and a highly non-linear environment. The movement of water is crucial, as is air and the currents, which are also 'fluids' (one science writer describes the atmosphere as an 'ocean in the sky'). There are also the mobilities of carbon wastes.

We can also 'follow the water' along multiple paths, as state changes or phase transitions in ice have cascading consequences for many far-away places. These sudden shifts re-arrange the affordances provided by the Earth for human and animal path building endeavours, and shake-up the rhythms and routines of movements that currently characterise socio-ecological life. 'As heat moves through landscapes it transforms them, and creates new relations, and new passages…' (Yusoff 2010: 302). The Arctic melt forces us to think space relationally (Massey 2005); as seas open up, permafrost cracks and land infrastructure is imperilled, and these shifts reverberate uncertainly across societies and economies.

I broaden the study of mobilities so as to include the Earth forces that enable and constrain human movement. To give an example, even walking is supported, not only by pavements and the infrastructure of pedestrianism, but by the Earth's gravity.

Examining mobilities in a context where many of the usual taken for granted 'supports' are not present (i.e. the medium of liquid water through which or with which ships are designed to move), forces us to appreciate the role of these taken-for-granted non-human forces that make movement and action possible. Following Cresswell and Martin (2013), I want to highlight the role of deviations and turbulence in mobility-systems, and not simply reliable, repetitious, routine 'laminar' flows and linear 'lines of transport' (Ingold 2007). Also, a circumpolar orientation resonates with David Bissell's call for mobilities research to highlight the circular or looping character of mobilities, rather than the point-to-point connections which inform much mobilities theory (Bissell 2013).

**Methods and mobilities**

> Studying the anthropocene is a real-time project (Whitehead 2015: 1)

As the preceding discussion has demonstrated a fundamental characteristic of the world is that it is on the move. By this I do not simply mean to designate the ubiquity of transport and communications processes that underpin contemporary life. More fundamentally, the research is underpinned by a mobile ontology which takes the constant, rhythmic, often turbulent deformation and reformation of the oceans as inspiration for how we grasp the social world, including life on land. Law and Urry argue that existing social science methods deal poorly:

> …with the fleeting - that which is here today yet gone tomorrow, only to reappear again the day after tomorrow. They deal poorly with the distributed – that is to be found here and there but not in-between – or that which slips and slides between one place and another. They deal poorly with the multiple –

> that which takes different shapes in different places. They deal with the non-causal, the chaotic, the complex (Law, Urry 2004: 403-4).

As Büscher et al argue the tendency amongst social scientists is to attempt to 'hold down' and 'dissect' fleeting, mobile and distributed phenomenon, and thus destroy the very dynamism that characterises the world (Büscher et al 2011). It is argued that traditional methods such as interviews, questionnaires, and archival research give only a posteriori reflections on previous events, divorced from the situations and movements that animated them. By breaking something down into its constituent parts and then trying to stich them all together again, traditional methods are reductionist and miss the dynamism which characterises the world, and thus, it is implied, are of limited use when tracing a moving world.

The challenges inherent in tracing a social world in motion are similar to the challenges encountered by oceanographers, where measurements made from ships of ocean currents' routes and velocity cannot be made as fast as the ocean changes. Scientists can't measure any aspect of ocean motion and expect to 'have it nailed for all time since a week later it will likely be behaving differently' (Murphy 2007: 44). Fluctuations in the forces acting on oceans such as winds, tides, air temperatures, even slight oscillations in Earth's orbit reverberate across the surface and in the interior of the ocean, some immediately and others in delayed response. Systems are usually dynamic and interact in ways that defy attempts to model them. Small deviations at the micro scale can resonate with events at larger scales and lead to new and unexpected outcomes. This is a problem that besets efforts to model climates.

In response to the perceived limitation of social science methods, recent years have witnessed the development and deployment of a range of 'mobile' and 'inventive' methods which attempt to ‘capture, track, simulate and shadow the many and interdependent forms of intermittent movement of people, images, information and objects’ (Büscher  et al 2011: 7. See also Lury et al 2012) These include methods such as ‘ride-alongs’ and ‘shadowing’, which enable researchers to ‘move along with, be with, or sense with’ research subjects (Merriman 2013). Innovative attempts have also been made to ‘follow the information’ (Büscher et al forthcoming), and technologies such as GPS and more recently drones have been enlisted to track moving research subjects and objects (see Büscher  et al 2011).

Yet Merriman argues that mobile ’methods have been deployed largely to understand the experiences and movements of embodied, mobile human subjects, which are increasingly praised and celebrated over-and-above studies of transport spaces, infrastructures and policies’ (Merriman 2013: 178). Yet the latter, rather than mobile subjects, are the central focus of this research. There are thus significant limitations to the employment of the kinds of mobile methods described above, for instance those which track moving subjects. First of all, the research sites are difficult to access, especially in the Arctic, and especially in the Russian Arctic. Secondly, being physically co-present with moving cargo would not yield the same insights that following passenger or tourism mobilities, like driving, cycling or yachting would, where a key feature is research subjects’ sensory experience. Whilst the sensory experience of seafarers is important in mapping maritime logistic assemblages, the processes being explored in this research cannot be reduced to or grasped in more ‘unmediated’ a fashion by *literally* moving with vessels, cargos and seafarers.

Merriman argues that:

> Mobilities criticises the tendency to focus on physically co-present and face-to-face interaction, yet the priority ascribed to phenomenological presence in research methods recreates this problematic tendency to treat the face-to-face as the main locus of action. Yet witnessing something first hand does not provide some authentic or singular way of witnessing or knowing a subject, thing or event… superior to other embodied practices such as reading about an event' (2013: 179).

A more expansive conception of mobile methods might therefore involve the creative 'mobilisation' of traditional research methods such as interviews and desk research, so as to shadow the fleeting, multiple and distributed. Indeed, 'traditional' methods could be made to form part of a mobile methods toolkit. More 'traditional' methods like 'interviews, textual analysis and historical written accounts and visual representations – official or unofficial, personal or public – provide a valuable insight into the practices, events, spaces and experiences relating to a particular activity' (Merriman 2013: 178). 'The Northern Sea Route' is massively distributed in space and time and difficult to get any 'closer to' by actually 'being there', wherever 'there' is. As Steinberg (2015) writes, direct access and experience of the sea remains impossible (although surfers and deep-sea divers might come close to such 'unmediated' access to the ocean deep). Experience of the sea is always mediated by the ship, or the submarine, or indeed the port. At the same time, it is unsure how experiencing the sea in an 'unmediated' way would bring one any closer to the object under investigation, as what is being investigated is precisely, the ways in which sea-space is 'mediated' in all sorts of ways, not only in the sense of being represented by texts, media and legal instruments, but also mediated by the objects and infrastructures which attempt to domesticate ocean surfaces or make icy waters serve as reliable 'sea lanes'.

The research attempts to track a world in motion, the emergence of a route, whose development is linked to and affected by many 'surrounding' activities and currents, both geographically proximate (occurring in Arctic/northern regions), and distant - but linked through various routes and relationships. The (re)emergence of the NSR is also temporally complex, involving currents sweeping through the present, but also events that took place and processes that were initiated long-ago, events the researcher can have no direct experience of and so must therefore seek some other means of entry. Understanding historical processes is crucial. The case study also involves conceptions of and expectations regarding the future, underpinned by new forms of 'seeing in advance' and statistical (i.e. climate) modelling. The taken-for-granted and by now mundane sociotechnical system of the internet, might be said to provide affordances for mapping a world-in-motion. The ability to publish and disseminate content in rapid timeframes and with global audiences, without the chokepoints and latencies associated with traditional publishing, not only makes possible a much more informed citizenry, but provides powerful tools to the researcher. The next section discusses some of the ways in which the internet can be used in social research.

**The Internet and research**

As Peters (2017: chapter 8) argues, the internet enables researchers to be more *adventurous* in the places and processes they are able to research. It enables communications with physically distant others (thus widening the field of possible research subjects) and 'imaginative travel' where one is able to visit 'virtually' places that by their very nature are difficult to access. Indeed, the entire research process has been thoroughly re-arranged (as has every other aspect of society) by the internet.

The internet can provide a powerful tool for researching shipping mobilities in particular. Vessel tracking websites such as www.marinetraffic.com monitors the position of seaborne traffic in 'real-time' using AIS (automatic identification system) signals, giving shipping and insurance companies, port authorities, enthusiasts and researchers unprecedented access to what would otherwise be hidden mobilities. There are numerous 'blackspots' created by this form of tracking, some vessels turn off their identification systems in order to evade detection (i.e. illegal fishing operations), and AIS coverage is more reliable in coastal areas, and the Arctic remains poorly covered by AIS and satellites. The lack of monitoring and the absence of statistics provided by such monitoring has major implications for insurance and marine spatial planning as examined in more detail in later chapters. Along with vessels, cargos can be traced, through buying information from companies such as Lloyds (a maritime insurance and consultancy firm). These processes take skills acquired through practice, refined skills in the arts of 'pattern recognition'. As a researcher from a leading environmental NGO explained:

> Re your question - where does information come from..? No simple answer to that! As far as I'm concerned it's a matter of slogging my way around the net. It used to be reference libraries, now it's the net. Phrase and re-phrase search queries, find one document or news story that leads you to another and so on. One document might use a graph which is pinched from another document or report - that 2nd paper is credited and off you go on another search. Rarely is everything laid out there for you, it's a matter of cross referencing this with that and drawing on a lot of experience of ship tracking, consignment following etc to try and make some sensible conclusions. A lot of information we buy - shipping movements from Lloyds. Import statistics from various sources (email exchange with author 2014).

Yet being able to track ships and cargos remotely, even when available, tells us little about the embodied dimensions of seafaring, and the broader social, political and economic contexts within which these movements occur. It might tell us about the where and when of movement, but little about how these movements are understood and imagined. Yet online news articles, interviews with experts, activists and policy-makers grant insight into the imaginaries, the legal and regulatory frameworks within which shape and animate these mobilities, as well as their associated controversies. Webpages are ‘potential sources of data in their own right’: web material ‘can be ‘mined’ for data that is relevant to a study, and then analysed in much the same way as textual material’ (Peters 2017: chapter 8: no page).

**Methods and sources**

How then has the research been carried out? I adopt an eclectic methodological approach, which seeks to multiply access points to the spatially and temporally complex phenomena under investigation, combining interviews and desk research. Much of the research is conventional enough in its methods, involving interviews in offices, via skype and desk research. Although effort was made to travel as a passenger on a cargo vessel traversing the NSR, these requests were turned down.  As part of the research a trip was made to the port of Kirkenes, 200 miles north of the Arctic Circle and increasingly figured as the first port of call of the NSR. The site visit involved carrying out interviews with logistics experts located in northern Norway, but the 1000 mile plus journey to and from the Arctic, was also a way of experiencing the transportation circuits, processes and procedures that link the Arctic to the rest of the large population centres of the south.

**Interviews**

I carried out semi-structured interviews with a range of actors, including NGOs, shipping companies, logistics experts, climate scientists and meteorologists. Given the relatively few numbers of vessels that have transited through the NSR, and individuals with expertise on the subject, the number of interviewees is relatively small. Nevertheless, 7 interviews with key experts on Arctic shipping and the NSR were conducted, each of which represent a unique vantage point on developments in Arctic shipping; these interviewees included 2 Arctic logistics experts (henceforth interviews A and B); an interview with a shipping agent from a key commercial actor the Tschudi Group (interview C); a captain of a ship (interview D); an environmental activist (interview E); a meteorologist (interview F); and a climate scientist (interview G). Informed consent was obtained both orally prior to the start of each interview and in writing. Ethical approval for the project was sought and granted by Lancaster University and conducted in accordance with the university's 'Code of Practice', as well as the ESRC'S Research Ethics Framework, which commits to respecting the dignity, rights and welfare of participants, as well as minimising risks to participants, researchers, and third parties.

Interviewees were identified and recruited in the following way. Web searches revealed a relatively few number of companies involved in, and experts commenting on, the NSR. Individuals were contacted initially via email and then via telephone. A snowball method was used whereby interviewees were asked if they could provide access to further interviewees. The interviews followed a semi-structured format, wherein initial lead question would spur open-ended discussion between myself and interviewees. Questions would usually centre firstly around the interviewees role/position, and how it is they came to be interested or involved in matters pertaining to Arctic shipping. Questions would then typically turn to interviewees involvement with, or opinions regarding the contemporary developments along the NSR (for instance, the interviewee's role in preparing a shipment through the NSR; describing the details of a journey and the actors involved as well as any obstacles faced). Interviews were transcribed, allowing the research encounters to be re-staged and analysed several times, showing the ways in which the ability to 'freeze' and preserve events in the form of recordings, offers opportunities as well as drawbacks, to return to the preceding discussion of methods.

The Arctic shipping expert community is relatively small and close-knit. Whilst this may be advantageous in terms of gaining access to key interviewees, it also means that one is being guided along already existing paths in a sense, with certain individuals and organisations effectively acting as 'gatekeepers', inevitably shaping the research process. On one occasion, after having arranged an interview and been 'vetted' by a shipping firm, the company informed me that there were certain topics that would be 'off-limits' for discussion during the interview, and in addition that someone from the firm's PR department would sit in on the interview, ensuring conversation did not veer 'off-topic'. Yet many of these actors turned out to be frank and open in the issues they were willing to discuss and information divulged. On several occasions, information was relayed to me 'off-the record'. Whilst this information remains strictly confidential, in accordance with the ethical framework guiding the research, such snippets gleamed 'off-record' were nevertheless helpful in re-orientating the research, gesturing to what might lie beyond official accounts.

Gaining access to certain actors was much more difficult. There are some conspicuous absences from the list of interviewees. Representatives from the nexus of Russian energy interests, who are – in a political and economic sense – key actors in the development of the NSR did not respond to requests for interviews. Neither are there any interviews with military actors. Neither are there any representatives from the Russian state. For instance, I contacted key firms in Arctic shipping and resource extraction, Gazprom and Rosneft, but my repeated requests for interviews were unreturned. In order to ‘follow’ or understand these kinds of actors, I am indebted to other academic and journalistic accounts. There we find fragments of information that the researcher can draw together from various sources, so as to build-up a picture of these notoriously secretive actors.

**Secondary sources**

The research draws significantly on secondary sources, including historical books, especially on the Arctic, on shipping, and on the history of Arctic sea routes. The NSR has a history, and understanding this history is crucial to understanding its present form and also the possibilities that are latent within it. Thus, the research partakes in a ‘return to the archive with new objects of study and new interpretive resources’ (Dittmer 2014: 396). As ‘each assemblage has its own particular historical trajectory... it becomes crucial to investigate the particularities of each’ (396). Thus, I am dependent on a small historical literature that has been produced on the NSR and on the Russian Arctic (in particular Basin et al 1988; Bobrick 1992; MaCannon 1997; Armstrong 2011). The research also ’mines’ the digital archive, including blogs, online newspapers, policy documents, NGO reports, business promotional literature, videos and presentations, working papers, interviews with experts, activists and policy-makers, an almost constant stream of ‘live’ information about events pertaining to the NSR and Arctic shipping networks.

These research materials were analysed through the identification of themes and clusters of related areas of interest. The identification of themes is a key part of qualitative research. The latter emerged initially through literature reviews, and then refined when combined with empirical findings (i.e. interview data). The research begun by consulting work in mobilities research, science and technology studies and work on globalisation and the extractive industries and. Shipping emerged as a key lacuna in the mobilities literature, and indeed in social science generally (see chapter two). The following themes and research clusters were identified: firstly; contemporary globalisation processes; secondly, the politics, economics and history of the Arctic region; thirdly, contemporary developments in shipping logistics and 'cargomobilities' and ocean space governance; fourthly a cluster of themes around 'the Anthropocene'. Richer literature investigations produce more themes, and the emergence of more themes produced further explorations and 'mining' of various literatures, which involved forays into geography, engineering, climate modelling, politics and economics, 'futures' studies.

A kind of metaphorical 'data mining' was employed, searching through hundreds of online documents. Key search terms entered into the 'Google' search engine were 'Northern Sea Route'; 'Arctic'; 'Shipping'; 'Russian Arctic'. 'Oil+gas+Arctic'. The searches followed an iterative process, such that as results were revealed and details regarding new developments came into view, search queries could be refined with more precision. For instance, search queries on oil and gas in the Russian Arctic would reveal information regarding specific fields; subsequent searches could be refined i.e. by searching using terms such as 'Sakhalin' or 'Prirazlomnoye' (the names of two Russian Arctic oil and gas facilities). Tools such as filtering by date were employed so that redundant information could be filtered out, and so that a picture could be built-up of the temporal evolution of developments surrounding the NSR.

There are drawbacks associated with leaning on secondary, particularly online sources, especially problems of reliability and accuracy. Journalistic material is not subject to peer-review and may uncritically accept information (such as statistics on ‘proven’ or estimated ‘recoverable’ oil and gas in a particular region of the sea). Such ‘biases’ can be addressed by cross-referencing and corroboration. Statistics regarding (for instance) the amount of recoverable oil and gas given in a particular news item were corroborated by statistics given in other sources, so as to ensure as much as possible the building-up of an accurate account. But the research is not primarily a study concerned with quantifying reserves of fossil fuels, or the volume of freight moved through ports. All statistical gathering procedures are subject to limitations, and this caveat applies to statistics used in this study. By definition statistics exclude, make cuts and ‘freeze’ the object under investigation.

**Conclusion to section**

Attempting to map movement or becoming is in many ways an impossible endeavour. For instance, efforts to track movements with GPS and other locational media encounter a paradox; they can reveal mobile processes that would otherwise remain hidden, but they can only do so through new ‘mappings’, plotting new points along a path, which of necessity arrest the movements and processes they attempt to capture. In between each instance are an infinity of others. Therefore, no matter how fine-grained one’s ability to ‘map’, movement cannot be sliced-up into a series of successive instances, as movement or life is not made of discrete moments but *is* continuous motion (Bergson 1911). Efforts to ‘capture’ change processes, worthwhile and indeed crucial as these efforts are, will never be anything other than approximations of much more complex and open-ended processes. Crucially this is not a ‘failure’, but inherent to modelling, mapping and describing. Thus, mobile methods’ inability to ‘capture’ processes of movement, and actually to reproduce new forms of stasis, should not be seen as ‘failures’ but as the precondition for being able to, at the very least, gesture to the messy, mobile and *analogue* processes which compose reality.

The ‘here today, gone tomorrow’ mentioned in the quote above, is a key characteristic of the sea-ice that is central feature of the spaces and processes being examined. Therefore, to a large extent I am dependent on the scientific methods employed by meteorologists, climate scientists and ‘ice-forecasters’. Challenging positivist conceptions of science, many scientists are working within the same paradigm of complexity and systems theory that have reoriented the social sciences, engage with a dynamic and vibrant materiality, as well as acknowledge uncertainty and provisionality, and might be said to be practicing a kind of ‘mobile methods’ (Murphy 2007). Rather than seek to open up each and every black box, and enquire into the ways in which the objects of science are constructed or co-enacted, the research adopts, where robust evidentiary standards have been met, an attitude of ‘trust’ to the findings of climate science or oceanography (Clark 2011: xvii-xx). Yet at the same time, the research explores the inevitable ‘cuts’ made by climate modelling processes. The interdisciplinary field of climate science attempts to model astonishingly complex inter and intra-actions. That the planet is heating is by now indisputable, but there is significant uncertainty regarding how these rises in global mean temperatures will play out in practice, given the sheer number of variables in play and their potential states. Thus, climate science confronts ‘an abyss whose reality becomes increasingly uncanny, not less, the more scientific instruments are able to probe it’ (Morton 2012, cited Clark 2014: 21). I adopt what might broadly be called a realist ontology. with ‘realisms’ of many different flavours enjoying increasing currency within social theory (e.g. Delanda 2006; Barad 2007; Harman 2007; Clark 2011; Bryant 2011; 2014). In contrast to older realisms rooted in scientific positivism however, emphasised is the provisional character of knowledge, the paradoxical nature of scientific endeavour, where uncertainty proliferates as the techniques used to probe the world become more refined. Such a realist approach accepts the provisional and ‘situated’ character of all knowledge (Haraway 1988). For instance, he ‘ocean turn’ I have documented is inextricably entangled with satellites which might be said to have modified the ‘optical unconscious (Krauss 1994)’, The birth of ocean science coincides with the start of the industrial revolution (Stel 2013: 196); oceanography and the climate sciences that in part emerged from them are products of the industrial revolution. There is therefore no transcendent point of view or knowledge from without or above (despite satellites!).

This chapter has demonstrated the fundamentally mobile character of spaces and societies, but also the ways in which mobilities are shaped and patterned in more or less enduring ways through routes. Stability or regularity results not so much from things staying still, but moving in repetitive and looping motions. I have argued for a mobile ontology which looks at the constant, rhythmic, but often turbulent deformation and reformation of the oceans as inspiration for how we grasp the social world, including life on land. The next chapter probes this ‘water world’ more deeply, paying particular attention to the domestication of the oceans and seas through the construction of routes.

## Chapter three: water worlds

> The sea is everything it is said to be: it provides unity, transport, the means of exchange and intercourse, if man is prepared to make an effort and pay a price. But is has also been the great divider, the obstacle that had to be overcome (Braudel 1995: 276).

### Introduction

The previous chapter examined mobile theories and methods, and the enmeshing of human collectives with various non-human elements, especially routes, resources and wastes.  Along with a 'mobilities' and a 'circumpolar' reorientation, I proposed a maritime reorientation in recognition that what we all-too reductively call 'Earth' is more of a 'water world' (Peters, Anderson 2014). The oceans cover 70% of the planet's surface. This chapter looks more closely at contemporary ocean space.  The oceans serve simultaneously as transportation surfaces – with an estimated 90% of cargo seaborne (George 2013), arenas of resource extraction (oil, gas, minerals and fish), energy generation (especially through wind-turbines) and depositories of wastes. Most fundamentally the oceans are central to the planet's climate system, redistributing heat across the world in such a way as to produce the relatively stable climate on which organised social life depends. The global mobilities of cargos and wastes as well as the circulation of water, heat and air, take place largely below the threshold of collective conscious awareness. Attention may be paid to variations in the weather, or to rises in the price of goods, but the extent to which ocean space and hydrological processes permeate societies is not commonly acknowledged.  The oceans and shipping are largely invisible, the seas 'forgotten' spaces (Sekula, Burch 2010) which becomes visible only at moments of disruption – or anticipated disruption, including moments (or anticipated moments) of creative disruption, innovation or change. Yet, volatility haunts ocean circuits this chapter shows, as a number of thresholds and tipping points are thought to be approaching, both in shipping and coupled ocean-atmosphere systems. The seas are also subject to complex and overlapping legal regimes and novel practices of 'zoning' which attempt to adjudicate between the conflicting imperatives, to simplify somewhat, of mobility and sovereignty.

The ocean has a paradoxical character. It simultaneously separates and connects. It is, or was, the great barrier dividing people and places, but has increasingly come to serve as the great facilitator of all sorts of cross-border exchanges, as diverse as consumer objects and invasive species; the ocean simultaneously provides the most efficacious of transportation surfaces, whilst also due to elemental turbulence and distances from concentrations of people, presents one of the most volatile environments for the maintenance of routes; and whilst in theory, the liquid oceans provide the most flexible means for moving cargo across distances (where there are many ways of getting from one place to another), in practice imperatives of speed funnel traffic through a small number of spaces, giving cargo shipping systems a 'semi-centralised' character, rendering them vulnerable to disruption.

The oceans and seas were long the great dividers of peoples. But starting around the 1450s new forms of navigation emerged which enabled taking to the high seas (Braudel 1995). Until very recently human engagement with the oceans remained, literally and figuratively 'at the surface'. Only relatively recently have people ventured away from the littoral regions and taken to the high seas. Only even more recently have underwater spaces been penetrated by people and machines; and only more recently still has semi-routine movement through the Polar Regions been established. Yet even today the vast majority of the ocean deep remains unexplored (Helmreich 2008). The oceans, this chapter demonstrates are much more frictional and a lot less 'liquid' than one might think. Across the social and natural sciences there is an increasing appreciation of the oceans' significance within global processes

(Stel 2013). We might even be able to speak of an ‘ocean turn’ resonating across the social and Earth System sciences (Broecker 2007). The sociotechnical and geophysical links between land, sea and air are very complex; if we take the oceans as our point of departure, we are soon brought to other spaces and realms.

**Maritime globalisation**

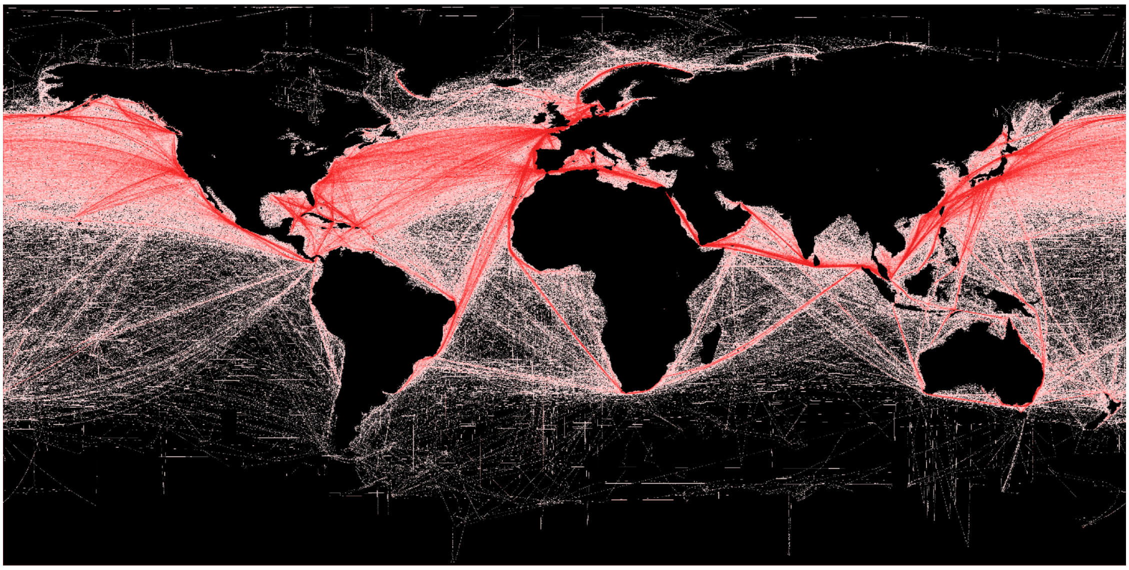

Figure 3.0. Global shipping traffic. Source: Wikimedia Commons

https://commons.wikimedia.org/wiki/File:Shipping_routes_red_black.png

Tens of thousands of container ships, oil tankers and bulk carriers ply the ‘sea lanes’, guided through increasingly crowded waters by new forms of routing enabled by the satellite networks that began to colonise the Earth’s orbit in the latter half of the 20th century. Whilst systems of ‘aeromobility’ (Cwerner et al 2009), and flight paths are key to the sorting and resorting of people (at least those able to move legally), non-human resources, products and components are brought into combination and recombination through shipping and sea lanes, which act as flexible ‘conveyor belts’ for a dispersed ‘global factory’ (Cowen 2014: 1-21). Thanks to innovations in cargo shipping – in particular the establishment of the system of containerisation - manufacturing has largely been outsourced, offshored and fragmented, taking place across many locations and numerous continents.

Resources and raw materials are extracted and shipped from all over the world. Cargo ships and oil tankers move through, with and sometimes against, turbulent spaces populated by mobile biological life, fishing trawlers, research vessels, migrant boats, warships, pirate vessels, submarines, oil platforms, wind turbines and undersea cables, to gesture to the incredible diversity of shipping mobilities and ocean-based systems populating the seas (Anim-Addo et al 2014).

Properly harnessed, the high seas provide unique affordances for moving ‘stuff’ cheaply and flexibly across continents. The origins of modern-day globalisation can be traced back to the ‘long sixteenth century’ (1450-1640), when innovations in navigation first allowed Europeans to establish paths through the high seas, first to Asia and then to the Americas. Europeans thus established a global network of routes and division of labour in which capital-intensive production was reserved for ‘core’ nodes, whilst ‘peripheral’ areas provided low-skill labour and raw materials, ‘centre-periphery’ relations which presupposed and produced huge inequalities between regions (Wallerstein 2011). 1492, the year of Columbus’ journey across the Atlantic and ‘discovery’ of the Americas, is increasingly recognised as a tipping point in the inauguration of the ‘Anthropocene’, not least of which due to the ways it precipitated an unprecedented remixing of marine biota in the process known as the ‘Columbian Exchange’, a major act of anthropogenic reshaping which left an unambiguous mark on the planet (Lewis, Maslin 2015). Global trade in this period was nevertheless limited to certain types of ‘cargo’ – especially slaves, silk, ‘chinaware’ and exotic spices.

In the 21$^{st}$ century, maritime trade is no longer a separate mercantilist endeavour, but plugged-into all aspects of life; the oceans have become the pre-eminent spaces of capitalist distribution (Steinberg 2001; Sekula, Burch 2010; George 2013), and cargos now include all the solid, liquid and gaseous materials that produce modern forms of life and underpin urban concentration. Shipping traffic has increased a staggering 300% since 1992, with even the world's most remote regions experiencing 'invasions' of ships and steep increases in shipping traffic, likely causing more water, air and noise pollution on the open ocean (Tournadre 2014). Yet at the same time cargo shipping remains relatively hidden or obscure. Whilst the manufacturing and consumption of consumer objects occurs at fixed locations and within eyesight, distribution takes place between locations, out to sea and out of sight, and is therefore the most difficult to capture of Marx's famous production-distribution-consumption triad (Marx 1993 81-113). One BBC article describes container shipping as the 'invisible network' that runs the world (Maughan 2015).

Mentz proffers the term 'wet globalization' to designate the ways in which 'the instantaneous globe of international finance— the globe that, as Gayatri Spivak says, "lives on our computers"— has always contained the ocean as its material substrate and mechanism' (Mentz 2015: no page). 'Microsoft provides the software that runs computers; Maersk bring us the computers', writes George. But 'whilst one is infamous, the other is somehow invisible' (George 2013: 7). Maersk are a key commercial actor in this world of 'maritime globalisation'. Maersk was founded in 1904 with just a single ship but is now the world's largest shipping company with a fleet of 600 vessels, active in 130 countries with around 117, 000 employees. As well as container shipping, Maersk also drills for oil and gas in Denmark, Angola, Brazil, Greenland, Qatar, Algeria, Norway and Iraq, the US and Kazakhstan. Its revenues in 2011 amounted to $60.2 billion, only slightly less than Microsoft (George 2013: 7). This diverse portfolio of activities where the same actors have interests in a range of separate but overlapping activities and 'sectors' is central to the political economies of the contemporary shipping business. The shipping business is made-up of vessel owners, charterers and cargo owners, but these distinctions are often blurred through joint ventures involving actors from across these groups (interview C).

Commercial ships follow established, dominant intra- and interoceanic trade routes that change over time, sometimes in precipitous fashion. The ‘main artery of globalisation’ is the Europe-Asia route, encompassing the Suez Canal. The Suez Canal shapes and channels global trade flows, and handles an astonishing 95 per cent of European member states trade by volume (Cowen 2014: 143). The Suez Canal marks the vast scale of the transport and communications infrastructure laid out between 1850 and 1870 ‘that was to be the foundation of a new world market and a new international division of labour’ (Harvey, cited Cowen 2014: 189). For Cowen, Suez is a ‘material marker of the deeply entangled histories of imperial trade and violence and a testament to a past filled with violent contests for control over this critical shipping corridor’ - most notably the Suez crisis of 1956 (2014: 143). The Suez Canal, ‘remains at the centre of corporate and military logistics today’ (189).

By cutting the distance between Europe and Asia by 43%, its opening in 1869 dramatically lowered the cost of moving goods between the two continents, and had an immediate effect on global trade patterns. Suez – like the Panama Canal– opened in 1914 which connects the Pacific and Caribbean (and greater Atlantic) oceans, transformed the dynamics of moving and making, as well as buying and selling goods, drawing distant places together and fuelling the emergence of national economies in the process. The Suez Canal can be traced back to 18th century efforts to establish quicker postal routes between Britain and France and their African and Asian colonies, and extend the reach of their respective Empires. Even with the first steam-powered ships it took a minimum of 113 days for post to travel between London and Calcutta around the Cape of Good Hope. A new route was devised using a mixture of seaborne and overland transport, using ships through the Nile and then carriages across the desert to the port of Suez, whereupon post could be reloaded onto ships bound for Asia. Whilst this route was not feasible for the transport of cargo, ‘…by creating a system of regular transportation a precedent was set, showing that a shorter route between Europe and the Orient was both feasible and desirable' (Karabell 2003: 79).

Prior to its construction one of the canal's architects, Frenchman Ferdinand de Lesseps, proclaimed that anyone 'preoccupied with questions of civilization and progress cannot look at a map and not be seized by a powerful desire to make disappear the only obstacle interfering with the flow of the commerce of the world' (cited in Karabell 2003: 78). 'Parting the desert' for the Suez Canal led to the expulsion of tens of thousands of local residents (Karabell 2003). The canal took 30 years to complete and cost the lives of thousands of labourers and slaves (Karabell 2003: 80-81). The canal was finished off with the help of fossil fuelled machines, which greatly hastened the completion of the project. Indeed, fossil fuels and the Suez Canal are deeply entwined. Not only was the project completed with coal-driven machines, but the canal itself helped facilitate an energetic transition from wind to coal in maritime transportation. Birtchnell and Urry explain:

> The Suez Canal emerged as key to the British Empire as steamships became the dominant form of ocean transport, principally because sailing ships could not pass through such narrow straits. Steamships could traverse open seas as well as narrow passes through key regional geopolitical shortcuts and this advantage proved to be a window of opportunity for a socio-technical transition from sail to steam (Birtchnell, Urry 2014: 3)

The canal was completed with the power of fossil fuels, encouraged a transition to fossil fuels in seaborne transportation, and also became a crucial route via which fossil fuels (particularly oil) came to be transported from the Middle East to Europe and the US. Today one quarter of the world's oil supplies moves through Suez, and a significant portion of the world's containerised freight. The lifeblood of oil moves through the aorta of globalisation. The canal therefore became a site of extraordinary strategic significance as it carried the energies states and militaries came to rely on. Fossil fuels have been central to the transformation of ocean space, not only through intentional acts like the construction of transoceanic canals, but also though the role played by carbon wastes in the re-composition of oceans waters through acidification, heating and rising sea levels (Vince 2015: chapter one).

Suez and the Panama canal, completed 30 years later, are the starkest instances of the 'will-to-connection' Simmel argued was such a pronounced tendency in human societies. Simmel argued that the bridge, as it 'connected the naturally unconnected' embodied this tendency most starkly. Simmel, like most social scientists remained 'sea-blind' (George 2013). Such canals divide the already connected in order to facilitate movement – and trade. Indeed, the will-to-connection is indelibly linked to the imperative to trade. In Old English, the word 'trade' meant both commerce and 'path' (Random House Webster's college dictionary 2000: 1385). The construction of Suez and Panama were examples of the re-shaping of geographies by the imperatives of speed and the desire to accelerate the throughput of goods and capital (Harvey 1989; Virilio 2006).

**Scale**

Figure 3.1 Triple E Class container ship. Source: Wikimedia Commons https://en.wikipedia.org/wiki/Maersk_Triple_E_class#/media/File:M%C3%A6rsk_Mc-Kinney_M%C3%B8ller.jpg

In the 21st century there are many more ships plying the sea lanes than at the time of Suez's opening, and these ships have increased enormously in size. As well as speed, *scale* is another imperative that powerfully shapes contemporary maritime trade geographies. Today the world's largest ship is the size of four football fields and can carry 19, 000 twenty-foot cargo containers (figure 3.1). These are as much 'floating warehouses' as ships, 'economies of scale made steel' (*Economist* editorial 2011). Finding quicker routes and speeding-up processes works alongside, and at times comes into conflict with, the quest for scale, a never-ending process which results in continuous expansions in the sizes of vessels and volumes of cargo being moved, bigger and deeper ports able to accommodate these ships and this volume of trade, and at the level of political and economic arrangements, the involvement of companies (like Maersk) in a diverse portfolio of activities (e.g. shipping, logistics, port ownership, resource extraction), in order to create commercial synergies and

‘spread the fixed costs of their operations’ (Levinson 2006: 233). The realisation of economies of scale means that it is still more profitable for certain cargos, generally non-containerised, bulk items like grain or raw materials, to travel to Asia from Europe via the Cape of Good Hope, the longer route around Africa which Suez supposedly replaced, as unlike Suez there are no limitations on the size of vessels able to travel this route. What is lost in speed is made up for in scale. The relative profitability of strategies of speed and scale respectively depend on the price of bunker fuel (Casey 2016). When oil prices are high, speed is a more significant consideration; when they are lower, scale. The Economist notes that “slow steaming,” a practice in the industry to save fuel, has caused the average transit time from China to Europe to increase from 21 to 26 days.
Whereas ships entering service in the 1970s could hold up to 3, 500 20 foot containers, by the 1980s they were carrying 4, 200 TEUs (twenty-foot equivalent units), and by 1988 they could no longer fit through the Panama Canal. Increases in size meant that container ships could not be used very flexibly, but these huge ships could provide massive cost savings if they travelled between deep-waters ports, which meant that ‘the major trade routes became fewer, but saw the passing of increasing numbers of ships between them’ (Hulme 2015: 66). In order to realise economies of scale, container ships travel in looping voyages along so-called ‘pendulum routes’, stopping at several ports of call along the way and back again. Containerisation thus effectively led to the establishment of new ‘power-geometries’ (Massey 1993), as the deep-water ports of Hong Kong, LA, Rotterdam, Antwerp, Yokohama and Felixstowe became key nodes in this world of maritime globalisation.

As a result of the increase in numbers of vessels and their volumetric expansion, the narrow, natural and manmade passages which provide speedy links between centres of production and consumption, like Suez, Panama, Hormuz and Malacca, obstruct global trade as much as they facilitate it, a point to which I return below. Yet, as well as large-scale transportation fixes other forms of *routing* or *insulation* have been devised to hasten, secure or 'smooth' the movement of cargo across the seas and across the land-sea interface. Crucial amongst these is the 'smooth' system of containerisation.

**Speed**

Containerisation has led to astounding increases in the volume and throughput of consumer objects moving through urban centres – and in combination with innovations in supply chain management, satellite tracking and software modelling, provides the infrastructural foundation for consumption cultures and practices of planned obsolescence (Leonard 2011; Holmes 2012). Containerisation is a product of continued exchange and repurposing between business and militaries. The first intermodal container system was used by US forces in WW2, but was then taken up Malcolm McLean in the 1950s, only to be further developed by US forces in Vietnam, before becoming the hegemonic system of global cargo distribution in the latter half of the 20th century. Containerisation integrates trains, trucks and ships and into a single system (Levinson 2006), forming globally extended paths that conjoin land and sea into continuous and smooth surfaces (Martin 2013) Containerisation – like automobility – is dependent on the resources of steel and petroleum, and indeed its architecture was modelled on the physical movement of liquid oil through pipelines. Oil *flows* efficaciously through enclosed and secure pipelines, insulating energy cargos from disruption or theft.

As Mitchell (2013: 27-39) documents, the transition to flowing oil from solid coal eliminated the need for the heavers and stokers that were necessary to coal, and who were a constant source of friction, using their position in the energy distribution network to exert pressure on employers for better pay and condition. Similarly, containerisation simplified loading/unloading routines, greatly reducing the time and labour needed to move cargo around the world. These routines were not only arduous but dockworkers (like those in Liverpool, London and Los Angeles), like coal workers and railwaymen, were a particularly militant segment of the labour force, and a key source of ‘friction’, which containerisation effectively eliminated (Mitchell 2013: chapter one). The quest to overcome bottlenecks and find short-cuts – to continually accelerate the turnover of cargo and capital – drive the evolution of cargo mobility systems.

The system of containerisation, no less than automobility, has a kind of self-replicating dynamism. Its reproduction involves more than just the conscious decision making of human actors. Like cars, which have facilitated the creation of patterns of sociospatial life (suburbanisation), that then call into being more cars, the ‘box’ (Levinson 2006) makes possible globally dispersed production networks that call into being ever increasing numbers of containers. There are now thought to be 17 million of these steel boxes circulating the world. Whilst containers are a means to an end, i.e. trade and the realisation of profit, the materiality of the box exerts its own pull, forcing action down new paths. A key problem which has emerged is where to store the build-up of empty containers (Nielson 2015). The material build-outs needed to handle increasing volumes of cargo, including the dredging of sea-lanes, widening road surfaces to accommodate, container trucks.

Containerisation might be said to complete the process initiated in the 1400s of turning the ocean from a space of separation to a space of connection (Hulme 2015: chapter three), turning turbulent oceans into smooth spaces of connection. However, containerisation has engendered new forms of turbulence. For instance, the sealing of container boxes from points of origin to destinations, means containers can also be harnessed for other, illicit purposes, like concealing and carrying contrabands and unauthorised flows of people (Parker 2012). Given the volume of containers moving through ports, checking the contents of each 'box' would incur costly delays. These are the runaway risks of 'liquid modernity' (Bauman 2001). Indeed, whilst liquids move more easily and efficaciously, liquids can also move turbulently and flow beyond control.

The paradigmatic example of such runaway risks is the *oil spill*. Oil moving through pipelines and tankers fuels the 'global factory' (Leonard 2010; Cowen 2014). The paths through which energy flows are some of the most significant and securitised in this 'water world'. Oil and oil products are the most traded commodities on the planet, accounting for a quarter of all seaborne trade. Ocean tanker routes connect producing zones like the Middle East with importing states like China and the US (French, Chambers 2010). Oil travels up from underground and undersea, along pipeline, tanker and train routes, from wells to refineries to factories to petrol stations to vehicles - and then transformed - into the air as carbon by-products. Oil's liquid character means that it can be transported cheaply and easily but is also liable to spill. Oil spills are an intrinsic part of the practice of moving oil. Moving oil means leaking oil. Given oil's mobility spills are irreversible, they cannot be 'undone'; Oil spills seep through densely connected webs of biological, social and economic life, affecting wildlife, fishing and tourism, and their toxic legacies spill disastrously into the future (see Digges 2015 on the on-going Deepwater Horizon disaster in the US. See also Watts 2012; Weszkalnys 2013 for social scientific discussions). Major oil spills percolate through global media channels and manifest on screens all over the world, making them disastrous PR for the carbon capitalist interests which organise and profit from oil production. Oil spills are symbolically potent and have played an important role in galvanising opposition to carbon capitalist activity, helping trigger the birth of the modern environmental movement (Mitchell 2011: 407).

Although the seas in theory provide the 'smoothest' and most fluid or flexible form of transport, where there are many possible ways to get from one location to another, in practice most shipping traffic is forced to pass through a limited number of shallow and increasingly congested channels close to land. The spaces where land and sea overlap, as repeated throughout the thesis, provide friction, compounded by the volume of trade and the size of ships.

**Maritime chokepoints**

Due to the characteristics of maritime space, the economics of transportation, and ever increasing sizes of ships, major maritime bottlenecks have emerged which render cargo flows vulnerable to disruption (Rodrigue et al 2009: 30-42). These chokepoints are often described as the 'Achilles' Heel' of the shipping system and global economy. They are 'tipping elements'. Vital to the global economy are a relatively small number of narrow straits, capes and passages which provide shortcuts between zones of consumption and areas of production, without which outsourcing of production would not be profitable, given the fuel costs that would be incurred by lengthy detours around continents. The 'new global spatial division of labour', with China the manufacturing hub of the whole world, is predicated on the continued availability of these passages. Most of the world's oil supplies pass through such spaces at some stage.

There are hundreds of narrow passages such as these around the world but a few only are 'chokepoints'. Major chokepoints include the Bosporus, just half a mile wide at its narrowest point, through which over 50,000 vessels pass each year; the Suez Canal, 1,000 feet at its narrowest and through which 3,000 oil tankers pass annually; the Strait of Hormuz, by far the world's most important chokepoint, with an oil flow of 16.5-17 million barrels per day; and the Malacca Strait (figure 3.2), the world's busiest waterway, through which passes 70% of China's and 80% of Japan's and

South Korea’s oil (EIA 2014a). Of the Malacca Strait French and Chambers write: ‘The whole economy of East Asia is increasingly at the mercy of a small stretch of sea, just 8, 000 feet at its narrowest point’ (French, Chambers 2010: 73). These bottlenecks are as much products of the volume of cargo and size of ships being moved through them as they are inherent features of physical geography. These spaces force already congested streams of traffic to converge, making movement particularly hazardous. They provide significant opportunities for sabotage, as well as increase the risks of accidents and spills.

Even a temporary blockage of one of these waterways, would likely lead to oil prices rises, and severely damage the economies of both producer and consumer nations, and reverberate throughout the whole world economy. China is dependent on oil imports coming by tanker from Africa and the Middle East. China’s energy demand predicted to double by 2040 (IEA 2014b). These shipments must transit through the Malacca Strait, stoking in China a sense of vulnerability and overreliance on unstable sources and potentially hostile maritime neighbours as the tankers traverse the South China Sea. The emergence of China as the ‘workshop of the world’ and the corollary increase in its manufacturing exports has been critical in making the oceans central to contemporary global processes. Europe-Asia routes, always central in histories of global trade, have become even more significant today.

Figure 3.2 The Strait of Malacca. Source: Wikimedia Commons

https://en.wikipedia.org/wiki/File:StraitOfMalacca2.jpg

Due to the prevalence of chokepoints the contemporary shipping system might best be described as a 'semi-centralised' network, with a number of highly sensitive pressure points presenting significant opportunities for control or disruption. Critically, the semi-centralised character of the network only increases the potential for volatility. The prevalence of congestion requires that we recognise the important role of bottlenecks and blockages in the production of twenty-first century (ocean) spaces. Flows 'freeze-over'. Similar to the phase transition undergone by a volatile as it switches between states, maritime traffic flows are prone to 'solidify' at certain points in the network. Yet this potential for blockage only contributes to the overall 'liveliness' of the oceans. Maritime chokepoints are a major source of volatility, and give an especially precarious character to distribution systems and distributive capitalism. Risks of spills, accidents and other 'turbulent mobilities' are increased at chokepoints demonstrating the recursive relationships between mobility/immobility, friction and flows. Blockages, bottlenecks and obstacles are one way in which the exigencies of matter exert a pull over events, forcing action literally down new paths.

Chokepoints emerge when imperatives of speed and scale discussed above come into conflict. Suez Canal has just been widened, and the Panama Canal is currently undergoing expansion. The expansion of Panama has triggered *a wave* of frenetic dredging activity along the Atlantic coast, as ports are forced to expand or face losing traffic to competitors. Thus, maritime trade geographies shift and undulate in relation to one another, with one major project having knock-on consequences for geographically dispersed yet topologically proximate locations. The Port of New York alone has moved some 42 million cubic yards of dirt over a decade in *anticipation* of the opening of an expanded Panama Canal, and the larger vessels that an expanded canal will bring (Maly 2015; Carse, Lewis, 2016). The geographies of trade now seem subject to the same accelerated cycles of upgrade and obsolescence as the goods that move through them, as canals are constantly widened, sea lanes dredged and ports' capacities increased in order to facilitate the extraordinary growth in maritime cargo flows

As well as increasing the capacity of existing infrastructure, anticipated blockages are driving the development of new routes the Northern Sea Route and Northwest Passage, and new overland and maritime Silk Roads, a point to which I return below.

**Elemental turbulence**

Elemental turbulence had previously meant that the oceans were spaces which separated rather than connected, and indeed the oceans' extraordinary geophysical turbulence continues to pose formidable problems for the establishment and maintenance of routes, nowhere more so, as we shall see, than the Polar Regions. Shipping is affected by the elements to a much greater extent than other mobility-systems, and this is in large part responsible for the danger and precariousness of movement through the seas. The sea is liable to 'withdraw its support at any time' (George 2013: 57). More so than human built roads surfaces for instance, the sea's behaviour is unpredictable. Elemental forces, storms, ice or changing conditions below the surface can force ships to capsize, lose cargo or deviate from prescribed routes. On average 2000 seafarers die at sea each year and an average of 2 ships are lost each week (George 2013). Over 3000 migrants were killed crossing the seas into Europe in 2014 alone, according to the International Organisation for Migration (see Charles Heller's film *Liquid Traces* on the death of migrants at sea). From her experience on-board a ship, George writes that 'every minute trouble is expected, from other ships, from unseen obstacles, from something that sailors call 'weather' but that is a more malign, more elemental version than the weather we have ashore' (George 2013: 21). The strongest storm is Force 12, where winds blow at more than 65 nautical miles an hour, filling the air with spray and seriously affecting visibility. A force 11 storm is thought to produce seas some 37 feet high. This kind of force is what Charles Dickens encountered when he sailed to America. The sailors on the sea called it 'weather':

> And so the ship goes on, staggering, heaving, wrestling, leaping, diving, jumping, pitching, rolling, and rocking; and going through all these movements, sometimes by turns, and sometimes together; until one feels disposed to roar for mercy (Dickens, cited George 2013: 34)

The inherent danger of the oceans is compounded both by socio-legal conditions and the vast distances that often separate ships from concentrations of people. Langewiesche (2004) describes the 'free-market seas' where regulations are lax, and danger increased. The imperatives of speed and scale often sit uneasily with safety at sea. The latest vessels are so big that there is significant uncertainty regarding how they will perform on the seas, especially in stormy weather. Emblematic of the spatial contradictions of cargo mobilities, and the at times conflicting imperatives of speed and scale, the shipping industry fret that one such vessel will capsize and block the entrance to a passage like Suez or Panama (Millman 2015). Those operating outside the bounds of legality altogether face even more exposure to the elements, forced to rely on clandestine smuggling networks using repurposed and barely seaworthy cargo ships, or ad-hoc arrangements involving small boats and dinghies capable of evading the mobile frontier of ‘fortress Europe’.

Nowhere are the elements’ capacity to disrupt shipping more evident than in the Arctic and ice-covered regions, where the smooth systems of logistics encounter limits in frozen ocean spaces, storms and fog. The frozen ocean is an obstacle to frictionless movement. A ‘surface’ that moves between solid and liquid, as do Arctic maritime spaces, poses all sorts of problems for the establishment of permanent sea lanes. In order to insulate vessels from the weather modern cargo ships are fed with weather forecasting information from satellites. As well as weather information (chapter five examines the nascent field of ‘ice-forecasting’), ships increasingly depend on satellites to chart courses, remain visible to search and rescue services, and are also used by states for surveillance purposes pertaining to border maintenance (see especially Peters 2014 on surveillance at sea). This means that by definition satellite services – due to the ways in which they make movements visible, are unavailable to those who seek to remain invisible, like migrant vessels and illegal fishing vessels. The so-called ‘dark fleet’ of illegal fishing trawlers makes up an estimated third of all global fishing activity (Gibbs 2014).

**Satellites and the ‘sea of data’**

Satellite vision makes shipping traffic legible and therefore manageable in new ways. Satellite observations now feed a ‘sea of data’ which accompanies physical movement through the oceans. This data is collected for a range of safety, surveillance, security, logistics, navigation, insurance and even hobbyist purposes.  Some of this data is privately owned or proprietary but much of it is open-source or openly available. For instance, website marinetraffic.com tracks vessels' positions, port arrivals and departures based on AIS (Automatic Identification System) data.

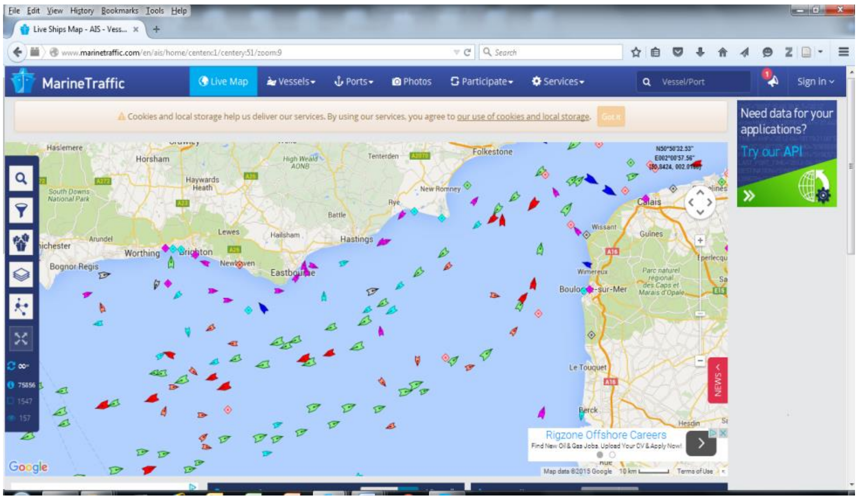


Figure 3.3 screenshot of vessels moving through the English Channel, one of the world's busiest shipping lanes. Source: www.marinetraffic.com: 20/09/2015).

Reliance on satellite networks means that shipping systems can be said to functionally encompass sections of outer space, with the expansion of cargo ships contrasting with miniaturisation in the field of satellite technology, with some 'nano-satellites' no bigger than bank cards (Economist 2014). Many of these satellites are military-owned but also serve civilian applications. Growing reliance on satellite networks for a range of communications, forecasting, positioning and surveillance applications make various systems vulnerable to 'extreme' weather events in orbital space, and is a growing concern for experts (Sample 2014). In March 2015, a US military owned satellite which provided real-time weather information suffered a 'catastrophic event' after a sudden temperature spike (Sky news 2015).

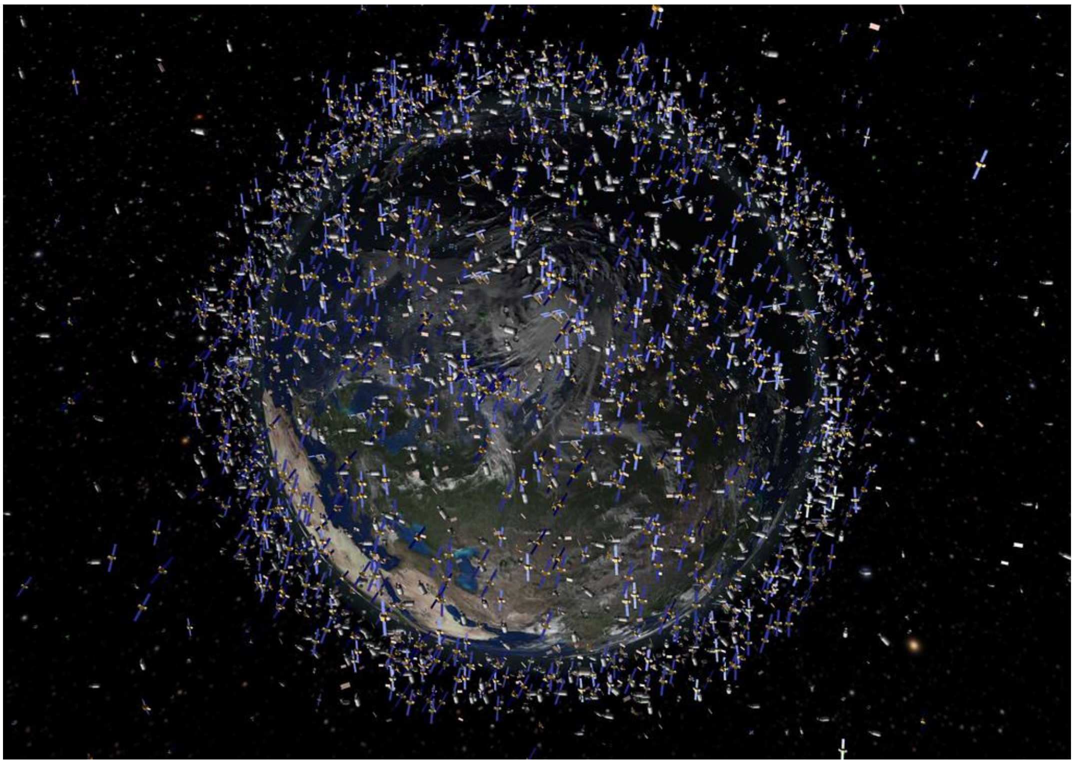

Figure 3.4. Credit: European Space Agency.https://www.flickr.com/photos/hopeful_in_nj/3273279798

The open accessibility of AIS data remains a source of controversy within the shipping industry. Making locational data freely and openly available makes vessels aware of each other's' positions, and is thus useful for safety and collision avoidance. Marinetraffic.com describes their operations as contributing to the 'efficiency and transparency of the shipping industry'. Many in the notoriously secretive shipping industries however worry that the open availability of ships' locational data exposes them to risk, especially from the new forms of maritime piracy that have arisen in the 21st century.

The 'sea of data' feeds insurance processes. Maritime insurance can be conceived as another 'strategy of insulation', isolating ships and cargos from the negative consequences of events such as accidents and attacks. Unsurprising given the inherent risks of the oceans, maritime insurance was one of the earliest forms of insurance developed. The biggest maritime insurance company is Lloyds of London. Through insurance cargo owners and vessel owners attempt to insulate themselves from the financial risks that come with accidents and disruptions. For the insurance industry, risk provides opportunities: ‘As an opportunity for profit, risk management seeks to transform an apparently negative order into one that enables the creation of value’ (Lobo-Guerrero 2008: 27). The insurance industry thrives under conditions of (relative) uncertainty; a certain world would not require the development of insurance. Insurance practices demonstrate the relativity of turbulence. What is a source of turbulence for vessel and cargo owners is part of the normal functioning of insurers (Cresswell, Martin 2012).

**Ocean-space governance**

The seas are increasingly subject to processes of legalisation and complex, often overlapping forms of ‘zoning’ (Dodds, Nuttall 2015: 41-46). Rather than the simple absence of regulation, there is ‘an ever more complex mosaic of governed spaces’ (Dodds, Nuttall 2015: 46). The establishment of the seas as the primary spaces of distributive capitalism rests on socio-legal as well as material-infrastructural bases. The notion of land as inherently amenable to territorialisation makes sense only in relation to an oceanic ‘other’ deemed by its very nature to resist such practices of enclosure (Connery 2001; Steinberg 2001). This land-sea binary underpins the ‘ideologies of land and sea’ central to the state system (Connery 2001). ‘This ocean concept’ argues Connery, ‘has been nearly inseparable from the history of the concept of the international as we know it’ (2001: 177). Notions of ‘free seas’, ‘freedom of navigation’ and ‘innocent passage’ inscribed in today’s ocean space governance instruments date back to the 1600s. The *Mare Liberum* principle was first advanced by Hugo Grotius in the early 1600s in order to justify an act of piracy, the seizing of a Portuguese Galleon in the Strait of Malacca by a Dutch privateer, and to counter claims of oceanic exclusivity by the Portuguese and Spanish (Langewiesche 2004:

36). This event turned out to be a tipping point in international maritime law (Stel 2013).

The main instrument of ocean-space governance today is UNCLOS (United Nations Conventions on Laws of the Seas), which came into force in 1994. UNCLOS provides the blueprint for the governance of the world oceans. One of its chief characteristics and consequences is the ‘zoning’ of ocean space, establishing the rights and responsibilities of coastal states and adjudicating between the conflicting imperatives of sovereignty and mobility, or ownership and access (Steinberg 2001). As the ‘high seas’ are customarily and legally configured as outside state jurisdiction, they are rendered exempt from many of the laws and regulations that govern land spaces. Use of the sea provides insulation to business interests from the friction associated with state regulation, enabling the circumvention of many costs and constraints. For instance, offshore carbon emissions are not regulated in the same way as they are on land, allowing ships to use inexpensive but especially polluting ‘bunker fuels’. Perhaps the starkest example of the fee-market seas is the ‘flags of convenience’ system of vessel registration, which emerged following WW2. Ships flying flags of convenience have no real nationality and are offshore and off-state (Langewiesche 2004). Like the outsourcing of production, this allows ship owners to ‘pick and choose’ states with the most favourable regulatory regimes. The largest of these offshore registrations are now Panama, Liberia, and the Marshall Islands, accounting for about two-fifths of all shipping. Registration with ‘flags of convenience’ is normally cheap and quick (sometimes taking only 24 hours), with no taxation and little regulation. Registries normally make no demands on the size or qualifications of the crew who are beyond the reach of national trade unions, health and safety standards, taxation or ship construction requirements, with crews drawn from pools of the world’s poor, mostly from Southeast Asia (Urry 2014: chap 9).

The designation of the high seas as 'international' spaces however, also provides favourable conditions within which piracy can flourish. The growth in seaborne trade over the last few decades seems to have 'generated' new forms of piracy, concentrated around the horn of Africa, Nigeria, and the Malacca Strait. The most sophisticated operations to date have been mounted by groups from the Puntland region, nominally part of the Somali Republic (Bahadur 2013). As attacks occur in transit spaces where the elements involved, i.e. ships and crews (as well as ocean-waters themselves) are highly mobile, effective prosecution of maritime piracy poses major challenges. It is difficult and expensive to reassemble all these elements in one place for the purposes of prosecution (i.e. crews have to be recalled and flown in from afar). Forensic operations are hampered as ocean-waters retain no traces of this activity. But the main problem is attributing jurisdictional responsibility for crimes committed in international waters. The UK has yet to prosecute successfully a single pirate (see discussion in George 2013: 142-147). Dawdy Argues: 'Piracy forces open the cracks of legal sovereignty, revealing an intensifying contradiction in what might be called neoliberal mercantilism' (2011: 361). Strategies of insulation devised to protect from the disruptions associated with maritime piracy include fortifying vessels with barbed wire, hiring armed guards on-board vessels and now the enlisting of warships and an entire naval armada patrolling the Gulf of Aden, orchestrated from a control room in a north London suburb (French, Chambers 2010; Marriott, Minio-Palluello 2012). Costly state intervention is thus necessary to protect the free-market seas! Nevertheless, piracy has imprinted itself on the global economic map. In Tournadre's 2014 study based on historical comparisons of satellite data, piracy hotspots around the coast of Somalia stood out due to the conspicuous absence of shipping traffic.

We have seen how the routes established across the oceans are frictional and turbulent spaces which are difficult to control, and which are approaching limits. Congestion, chokepoints and piracy threaten the smooth circulation of cargo on which ‘supply-chain capitalism’ (Tsing 2012) rests. As well as increasing the capacity of existing infrastructure, disruptions and anticipated blockages are driving the development of a range of new cargo routes, across the seas, across land and across ice. The (re) emergence of the Northern Sea Route is examined in more detail in the next chapter, but here I detail some alternative passages that are being developed.

**Old passages return**

New routes are being developed that would circumvent the pressure points in the global cargo network, offer more redundancy to a tight system, and help insulate cargo flows from possible disruptions of piracy, and also provide ways and opportunities for states to extend their geopolitical reach and influence. In order to increase the security of its oil supplies China, is in the process of completing the Myanmar-China Oil and Gas Pipeline in 2013, two parallel oil and gas pipelines that stretch from Myanmar's ports in the Bay of Bengal to the Yunnan province of China. The oil pipeline will be an alternative transport route for crude oil imports from the Middle East to potentially bypass the Strait of Malacca.

Routes appear and disappear but leave traces. These traces might be said to exert a pull, hailing people. In contrast to the remorselessly functional character of cargo ships and port infrastructure, there is often immense symbolism associated with new and experimental trade routes, those routes which have not yet become routine especially those with a long history. This symbolism is especially a feature of the Arctic passages, caught-up as they are with legacies of exploration and adventure, involving many fabled (and doomed!) voyages of exploration.

Being developed by the Chinese state are the ‘New Silk Road’ and ‘New Maritime Silk Road’ initiatives, which might in some ways be seen as re-workings of ancient trade routes. The combination of novelty with the historical resonances of these routes mean they attract a high level of visibility compared with routine passages. The Silk Road and Maritime Silk Road combined (dubbed ‘one belt, one road’ by the Chinese government) will create a massive circuit linking land and sea spaces across three continents (figure 3.5), and involves new transportation links, ports, trade zones, as well as new and strengthened diplomatic and cultural ties (Tiezzi 2014). The ‘new Silk Roads’ represent a novel shift in forms of territoriality, as it would form a transnational yet semi-Chinese zone, spanning all the way from northern China to southern Europe. In December 2014, a train journey made its way across 8, 111 miles from Yiwu in coastal China to Spain, passing through Kazakhstan, Russia, Belarus, Poland, Germany and France before arriving at a terminal in Madrid. The new Silk Road is as much a cultural as an infrastructural phenomenon. Chinese state TV has a weekly television show which promises to ‘unearth the secrets and mysteries of this ancient route’ (Tiezzi 2014: no page). The ‘one-belt-one road’ initiative appears to be as much about carving out a sense of Chinese nationhood in a global world - linking China to both its neighbours and its past - as it is about constructing cargo routes. The other major alternatives to congested Europe-Asia sea routes are currently being carved through an unevenly melting Arctic, which we examine in more detail in the next chapter.

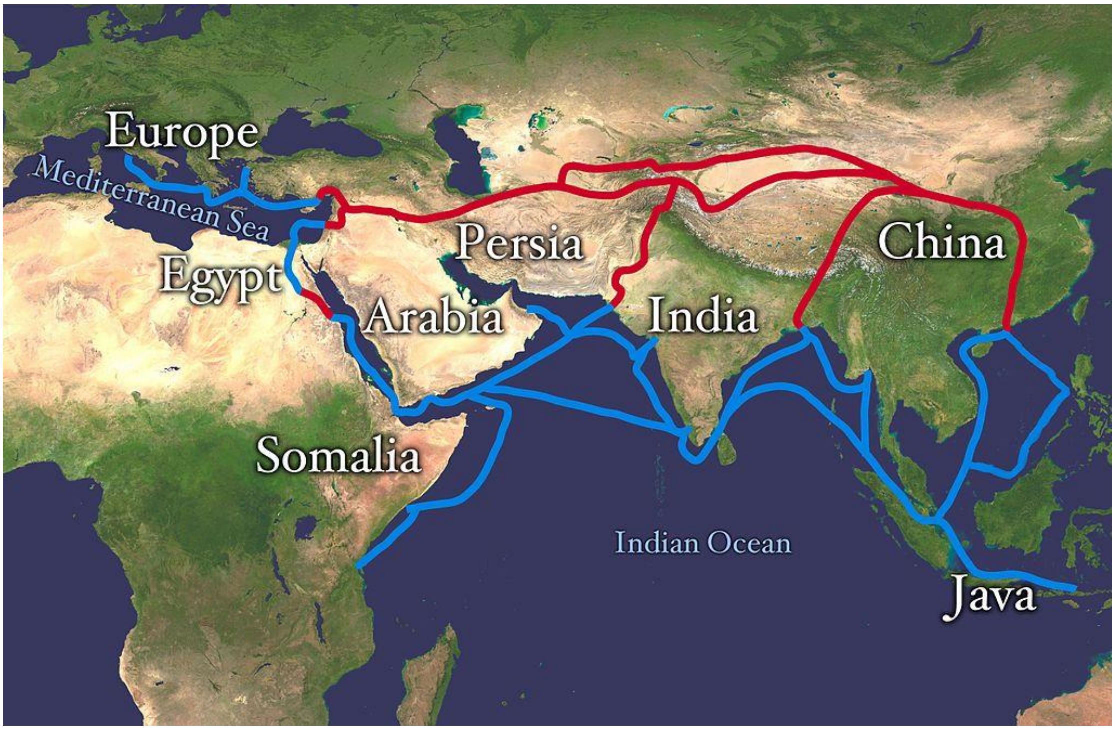


Figure 3. 5. Silk Road Economic Belt and Maritime Silk Road. Source: Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Silk_route.jpg

This can be seen as an emerging 'infrastructural geopolitics', as these routes can be seen as a crucial medium through which states seek to exercise 'soft power', extending their geopolitical reach and influence through links and diplomacy rather than military force or coercion. However, the lines between 'soft' and 'hard' power are ultimately blurred, especially given the shared lineages between civilian and military logistics infrastructure (Cowen 2014). This has led to fears that China's plans amount to a 'String of Pearls' strategy, involving the acquisition of ports and bases along the sea routes linking to the Middle East, potentially threatening the 'free seas' and 'freedom of navigation' doctrines.

**'Sea power'**

The seas are often figured as spaces which enable the circumvention of states' power and lie outside of sovereign jurisdiction. For instance in Foucault's (1986) notion of the seas and ships as 'heterotopic spaces', and Langewiesche's more recent (2004) conception of the 'outlaw sea', Foucault celebrates their liberatory potentials, whilst

Langewiesche stresses contemporary oceans' dystopic character, yet both accounts share an insistence on the oceans as beyond the reach of states. However, the seas have also been crucial spaces for the projection of state power. 19th century US naval strategist Alfred Thayer Mahan referred to the harnessing of the oceans in this way as 'sea-power' (Mahan 1894). Following military strategist Jomini, Mahan emphasised strategic locations (such as chokepoints, canals, and coaling stations), as well as quantifiable levels of fighting power in a fleet. Controlling the seas – the access points to land – or what he called the 'maritime highways' was key to maintaining global military hegemony. Ironically, the designation of the high seas as 'international spaces' – outside state control – makes possible this projection of state power. Indeed, the 'freedom of navigation' principles enshrined in international maritime law might be seen as a key ideological means through which US global hegemony is preserved. Langewiesche describes the notion of 'freedom of navigation' as 'power posing as principle' (2004: 37). Mahan's notion of sea-power encompasses both military and commercial activity and assets.

> Sea power in the broad sense, which includes not only the military strength afloat, that rules the sea or any part of it by force of arms, but also the peaceful commerce and shipping from which alone a military fleet naturally… springs, and on which it securely rests (Mahan 1894: 28).

Mahan argued that where peaceful shipping went, militaries followed, leading to the acquisition of bases along trade routes. The potential convertibility, given their shared technical lineage, of facilities like container ports and landing strips, from civilian into military infrastructure, is highly significant. Mahan conceived the oceans as comprised of sea lanes or 'sea lines of communication'. Mahan's sea-power discourse naturalises 'sea lanes' as pre-existing features of the oceans, which are then figured as central to control or keep clear for access. Mahan's doctrine was highly influential.

Indeed the construction of the Panama Canal was financed by the US in large part to extend the reach of US sea-power (Mccullough 1977). Mahan's theories continue to be influential in the 21st century, when the seas have become even more significant to global political, military and economic processes. Today the US controls and polices the global seas, thus exerting force by the threat of a highly mobile (oil-fuelled) navy, one that crucially also enables air-power to travel, via aircraft carriers, allowing air strikes to be launch virtually anywhere in the world. This coupled naval-aerial military mobility-system is crucial to the maintenance of US global hegemony. Today submarines, as well as underwater and aerial drones further extend the volumetric reach of this military assemblage. 'With submarines and increasing subsea activities human control and navigation of ocean space … cannot be restricted to its surface' argue Peters, and Steinberg (2015: 7). Gaston Gordillo notes that submarines mark 'a fundamental breakthrough in the projective territoriality of ocean space. Once a terra incognita of the planet, oceans now (re)present a space that can be occupied, harnessed, and utilised by different actors "in any direction"—up or down, ahead or behind, under or over, left or right (Gordillo cited Peters, Steinberg 2015: 7).

Systematically harnessing the high seas for the projection of imperial power was arguably refined by the Portuguese in the 1400s. The closing to Europeans of the overland Silk Road by the Moors in 1453 led to a surge of journeys in search of a new route to Asia. John Law wrote about the ways in which the Portuguese were able to exert control over distant people and places through the establishment and maintenance of what he called 'clear lines of communications', which enabled emissaries, information and equipment to move reliably between Portugal and its colonies (Law 1986). Crucial to this was the development of '…novel ways of borrowing the power of the wind and using it to exert force upon the sea' (Law 1986: no page; Delanda 1997). Ships were carried along by the 'trade winds' as sailors named them, which allowed European merchants to navigate the north and south

Atlantic oceans as early as the 15th century. The ‘Portuguese incorporated these trade winds within the Carreira… and therefore increased the size of the envelope within which the vessel might move and maintain its integrity’ (Law 1986: 4

According to Delanda, the harnessing of the energies of the Gulf Stream ‘allowed the conversion of an entire continent into a rich supply zone to fuel the growth of European cities’ (Delanda 1997: 53; Braudel 1994: chapter 4;). The paths devised by European merchants and explorers were then dependent on other kinds of ‘paths’, through which heat and energy are distributed around the globe. Through being enlisted in imperial ventures, ocean currents came to play a significant role in shaping the political map of the world. Geopolitics, geoeconomics, and geophysics were, and as the chapters that follow demonstrate, continue to be, utterly entangled, with the ability to harness energy flows central to geopolitical processes. However, today’s equivalent of the Galleons and the commercial and imperialist ventures they embodied, depend on fossil energies, and are thus liberated from the winds, but tethered to the bowels of the Earth (Sekula 1994).  Today sea-power continues to be crucial to the exercise of global military and economic power. Yet the energies harnessed today are no longer those simply of the oceans or wind-circuits. Today cargo ships and the war ships that shadow them are fossil-fuelled. The routes of the British navy thus had to be altered according to the location of coaling stations.

The preceding discussion on the ways in which states have used the oceans as ways of projecting power and influence, shows that the oceans cannot be seen as in any simple sense ‘beyond the reach of states’. Indeed the oceans today are subject to new forms of territorialisation. The primary instrument of ocean space governance, UNCLOS, attempts to balance the conflicting imperatives of transit and sovereignty. Whilst ‘innocent passage’ remains a pillar of UNCLOS, there are measures and provisions included in the legislation which entail new forms of enclosure or territorialisation of ocean space. States are granted a 200-nautical mile ‘Exclusive Economic Zones’ within which states have rights over all resources including under the sea bed. The EEZ provision extends state jurisdiction (if not sovereignty) over ocean space beyond the customary 12-mile limit (based on the range of a cannon shot), although states remain obliged to allow ‘innocent passage’ (defined as shipping traffic not ‘considered to be prejudicial to the peace, good order or security of the coastal State’ of trading vessels (UNCLOS 1994: article 19). These provisions make sense in relation to new technological means for finding and extracting resources from under the seabed. The oceans are thus no longer purely spaces of routes and mobilities, but also spaces of stationary and semi-stationary activity, resource extraction such as hydrocarbons, minerals, as well as ‘industrial’ fishing activity and energy generation (wind farms) activity, crowding ocean space in historically unprecedented ways (see Werber 2015 on the especially crowded North Sea). Fish are an increasingly significant ‘energy resource’ for human bodies, and fish is now the main source of protein for 1 billion of the Earth’s population (urbanisation appears to be associated with increases in protein consumption). Offshore oil and gas extraction now accounts for some 30% of global output (IEA 2014). Although operations are more risky, offshore extraction allows carbon capitalist interests to circumvent state regulations.

I have detailed the significance of the oceans as surfaces for the construction of anthropogenic routes, and the importance of the maritime world to globalisation. Routes through the sea sustain life on land, and have long been object of geopolitics. In the social sciences there has been an increasing awareness of the oceans’ significance. Moreover, the oceans are also increasingly recognised as playing a central role in ‘the Earth’s’ climate system.

## Oceans and climate

For a long time the oceans' role in the climate system was neglected, much as they had been in the social sciences. According to Murphy however 'a concept of climate that ignores the oceans makes no more sense than one that excludes the air' (Murphy 2007: 3). The ocean covers 71 percent of the planet and holds 97 percent of its water, making the ocean a key factor in the storage and transfer of heat energy across the globe. The wind circuits European explorers and colonialists learnt to harness are now recognised as central components in the Earth's climate system. Indeed, knowledge of these circuits and their importance for global weather patterns was initially acquired through journeys of exploration, which were always closely tethered to colonialist ventures. The log-books first employed by navigators during the age of discovery, and especially the more systematised and extensive system of record-keeping employed by the British Navy during WW1, have both been crucial in reconstructing knowledge about past climates (Murphy 29-41). More recently, following a storm which capsized a cargo ship in 1992, oceanographers traced the movements of one its cargos that had been ejected in the accident, 28, 000 rubber ducks (Ebbesmeyer, Scigliano 2009). By tracking these floating plastic toys oceanographers were able to refine ocean current models. There is thus a confluence between moving through and knowing the oceans, such that embodied contact and real-time experimentation remain the most effective ways of knowing ocean-space. Today, the oceans are continuously monitored by satellites and fleets of robots that provide real-time information and forecasts on the ocean's future states. Oceanography and climate science are inextricably entangled.

Mass flows of water, or currents, are essential to understanding how heat energy moves between the Earth's water bodies, landmasses, and atmosphere. Broecker employs the metaphor of 'conveyor belts' to describe these currents. Others describe them as akin to 'giant blood vessels' (Murphy 2007). What we might call the aorta of these global circuits is the Gulf Stream, which Murphy describes as '…a magnificent piece of nature, no less than the great terrestrial treasures Yosemite, the Grand Canyon, or Niagra, harder to appreciate but infinitely more influential in our lives' (Murphy 2007: 94-95). Wind currents challenge our notions of permanence and place.

The vast network formed by the world's ocean currents combined is known technically as the Thermohaline Circulation or more simply the 'great ocean conveyor belt' (Broecker 2007). The notion of an ocean conveyor belt conceives the world's seas as fundamentally interconnected or globalised. This conveyor belt is enmeshed with atmospheric circulation, and scientists now refer to this as a coupled atmosphere-hydrosphere system (Broecker 2007). The 'conveyor belt' metaphor invites us to recognise the central role played by the natural 'forces of production' which undergird the 'social forces of production' central to Marxist theory. The 'conveyor belt' metaphor also testifies to the situated character of scientific knowledge 'production', the way science is enmeshed with and emerges from prevailing social, political and economic conditions. It is no accident that notions of globalised oceans and ocean-conveyor belts emerged concomitant with social and economic globalisation.

The great ocean conveyor belt is now recognised as a fundamental climatological agent, as by distributing ocean water across the globe, it stabilises the world's climate. This entity is fundamentally fragile however. In the words of Broecker it is the 'Achilles Heel of our climate system' (1997). Temperature rises could lead to the disruption or even breakdown of the conveyor belt, with one extreme possibility being the sudden onset of a new ice-age. Ocean and atmospheric mechanisms are fundamentally interlocked, yet the precise manner of connection remains obscured by layers of complexity that blur distinctions between cause and effect:

> Because oceans are so much denser than air, they are able to contain and store far more heat than the atmosphere. The atmosphere is nimble, heating and cooling on the spot… moving of course far faster than oceans. Yet it takes

> ages for the atmosphere to change the surface temperature of the ocean over any significant area. So the atmosphere is running the show in the short term. In the long run the ocean rules. What ultimately determines climate as far as humans and the rest of life on the planet are concerned is the long-term temperature at the surface of the Earth. Yet the temperature is related to the ocean and its transport of heat… (Murphy 2007; 233).

The oceans also play a crucial role in absorbing carbon dioxide, and are thus central to the 'time-delay' effects of climate change, the lag between the causes and consequences of carbon emissions. Yet the ocean cannot continue to absorb carbon at the rate at which it is being emitted. Carbon emissions have altered the chemical composition of the oceans, a led to 'ocean acidification' processes. The crucial question is how much the oceans will continue to absorb before runaway climate feedbacks are set in motion, or tipping points crossed (IPCC 2014: chapter six).

**Conclusion**

Anthopocene write Gaia Vince writes that:

> Where the oceans separated land-masses we have joined them with bridges and tunnels; in the process endemic biodiversity has been diluted and dispersed; where continents separated oceans, we have connected them with tunnels. Perhaps our biggest changes can be seen in the Arctic, a place composed almost entirely of ocean, where vast expanses of ice made entire regions impassable year round. Now the oceans are being melted so that ship travel and drilling for oil and minerals are possible (Vince 2015: 151).

Unlike paths etched through landscapes, the oceans retain no footprints. The volume of shipping traffic increased by a staggering 300% between 1992 and 2012, , likely causing more water, air and noise pollution on the open seas (Tournadre 2014). And the dredging activity necessary to accommodate ever-increasing flows of freight means that seascapes will bear marks long after the activities which gave rise to them cease. Thousands of years from now, archaeologists will be able to find the channels carved through the oceans by the movement of 'stuff' (Maly 2015). The 'will-to-connection' Simmel describes has led to the profound reshaping of land and seascapes, both directly through building canals, digging ports, dredging sea lanes, and indirectly, through the waste products produced by transportation and industrial activity both on and offshore. Shipping is an important contributor to greenhouse gas emissions especially as the cheap bunker fuels spew soot or black carbon, which is now thought to be a much more important climate forcing agent than previously thought (Bond et al 2013).

The transformation of the oceans also includes the proliferation of immobile structures such as oil rigs and wind turbines. We might say that the oceans in the Anthropoceneare urbanising, mirroring and reproducing the urbanisation processes occurring on land (the term 'sea sprawl' is often used to designate this crowding of the oceans with moving and stationary industrial objects). In fact one could theorise the contemporary oceans, as well as specific underground, aerial and atmospheric spaces, as forming part of extended city cores, which not only now spread outwards to encompass rural and maritime hinterlands, but also vertically or volumetrically, upwards and downwards. According to Brenner contemporary cities functionally encompass '…intercontinental transportation corridors, transoceanic shipping lanes, large-scale energy circuits and communications infrastructures, underground landscapes of resource extraction, satellite orbits, and even the biosphere itself' (2013: 103).

Suez's opening in the late 19th century not only facilitated the global movement of goods, but the massive transfer of invasive species. Some 350 non-native species are thought to have entered the Mediterranean via the Canal, many of which pose significant threats to human health and local ecosystems (Galil et al 2007). Anthropocene  oceans are exemplified by ocean acidification, plastics accumulations, invasive species, overfishing, oil spills and sunken radioactive wastes. And climate change processes are melting sections of frozen water, and producing sea level rises. Sea levels are rising at 3.5 millimetres per year, roughly twice rate during 21st century (Watson et al et al 2015). These ocean hazards and risks move through biogeophysical ecologies and cross boundaries between states, between species, between the natural and the artificial demonstrating the ‘runaway’, cascading or emergent qualities that characterise risks in ‘liquid modern’ times (Bauman 2001).

One of the starkest examples of the Anthropocene oceans is the huge, floating plastic ‘island’ the Pacific Gyre, which is roughly the size of Texas. Plastics accumulations contribute to ocean acidification, and broken down plastics can become ingested by fish, which once caught in the net of one the tens of thousands of trawlers which scour the oceans, can in turn find their way into human stomachs, in a strange return of the discarded which confounds distinctions between ‘near’ and ‘far’, ‘inside’ and ‘outside’. Yet plastic accumulations such as the Pacific Gyre have now become resting spaces for birds, forming new ecologies which confound distinctions between the ‘natural’ and ‘artificial’.

Recent events around the South China Sea embody the enmeshing of ecologies, environments and geopolitics characteristic of contemporary ocean space in particularly stark and interesting ways.  China has embarked on an ambitious programme of island ‘construction’ as a way of bolstering its territorial claims over a disputed section of the South China Sea (Holmes 2015). Satellite images of the South China Sea show rapid destruction of some of the most biodiverse coral reefs in the world. The reclamation of land in the contested Spratly archipelago to build runways, military outposts and even small towns is endangering ecosystems that are key to maintaining world fish stocks and biodiversity. Six countries – China, Vietnam, Malaysia, the Philippines, Taiwan and Brunei – have competing claims to the more than 250 islands, reefs and sandbars in the South China Sea. The islands are mostly uninhabited but rapid reclamation is endangering ecosystems that are key to maintaining world fish stocks and biodiversity. The dispute, which has now drawn in the US, is complicated by untapped oil and gas reserves below the South China Sea, which is also one of the most lucrative shipping channels in the world. Coral reefs in the South China Sea are threatened by overfishing and climate change, additional impact of massive amounts of dredging to create new military outposts, will imperil these reefs even further according to scientists (see Whaley 2015). The South China Sea also accounts for 10% of global fish stocks, estimates the UN environment programme.

But is the Arctic where the relations between human collectives and the oceans, characterised by positive feedbacks, uncertainty and impending tipping points is most evident. The Arctic is heating at twice the rate of the rest of the planet, leading sea-ice to melt and making navigable waters appear. The domestication of ocean-space, whereby the oceans are turned from spaces of division to spaces of connection, which was initiated in the 1400s with the development of techniques for navigating the deep seas by harnessing wind-circuits, and continued with the development of fossil-fuelled ships and the construction of the Suez and Panama canals in the 1800s and 1900s, might be said to have reached a new nadir with the opening of circumpolar routes. This chapter has examined a range of approaching limits in both the global shipping system and global climate systems. The developments documented demonstrate that the designation of the oceans as somehow external to global social processes is no longer tenable. The next chapter examines the ‘Anthropocene Arctic’ and introduces the Northern Sea Route.

**Chapter four: 'a new Arctic'**

> The Arctic is changing so fast that no one – not the politicians who want to control it, the oilmen who want to exploit it, or the indigenous people that call it home – can keep up (Anderson 2009: 9).

The previous chapter examined twenty-first century ocean space and especially the routes carved through it. The oceans are implicitly designated as somehow outside societies, and have up until now received little social scientific attention. I finished the last chapter by discussing the 'oceans in the Anthropocene', arguing that it is no longer possible, if it ever was, to figure the oceans as purely 'natural' spaces, as they have been irreversibly transformed by anthropogenic activities. Consideration of the contemporary oceans leads us to the Arctic, a largely maritime region – but an unusual one in that it is solid for much of the year. The domestication of ocean-space, whereby the oceans are turned from spaces of division to spaces of connection, which was initiated in the 1400s with the development of techniques for navigating the high seas, continuing with the construction of the Suez and Panama canals, the development of fossil-fuelled ships, and the establishment of containerisation, might be said to have reached a new nadir with the opening of navigable routes through the Arctic. Yet as this chapter demonstrates efforts to establish circumpolar sea routes have a long history, histories that are linked to imperial projects and the exploitation of the Arctic's resources. Yet 'frozen oceans' have long proved particularly resistant to the establishment of paths and the extraction of resources.

Like the liquid oceans, the Arctic is another peripheral space in the social sciences, implicitly designated either as an unchanging and pristine natural wilderness, or a barren and uninteresting 'wasteland'. Whilst the Arctic is indeed one of the most sparsely populated and least built-up places on Earth (the infrastructures which cover so much else of the world are noticeably missing from vast swathes of the Arctic), the notion of the Arctic as unchanging is mistaken. The Arctic is one of the world's most dynamic geophysical environments, whose seasonal shifts are far more dramatic than almost any place else on Earth. Whilst sparsely populated, there are significant numbers of nomadic and semi-nomadic peoples for whom the Arctic is home, with their own cultures, histories and evolving social practices. The Arctic has also long been a 'meeting place' for diverse Eurasian, North American and Asian peoples, engaging in trade, barter and cultural exchanges. Rather than being peripheral, the Arctic has long been tied to the global economy (Heininen, Southcott 2010). Globalisation is frequently understood in terms of intense yet uneven flows of people, capital, goods, information, services and technology between national territories. An estimated 230 billion US dollars is generated annually on the basis of intensive exploitation and export of energy sources on domestic and international markets (Heininen 2005). Indeed, the Arctic is 'ever more entangled with the south and ever more at the mercy of decisions made elsewhere…' (Anderson 2009: 9). In August 2015 US President Obama gave the go-ahead, despite wide-spread condemnation from environmental groups, for Shell to re commence its Arctic exploration programme. Shell was granted permission to drill into oil-bearing rock around 8,000 feet below the ocean floor, at a drilling site 70 miles off the Alaskan coast. As the ice retreats, oil and gas resources from under the seabed are thought to be becoming more accessible, enabling the extraction and burning of more carbon and the production of more atmospheric C02, in a feedback process being described as the 'Arctic paradox'.

**Defining the Arctic**

Perhaps even more than other regions of the world, the Arctic is difficult to define or to 'hold still'. Many criteria have been used to delineate the Arctic. None of them has achieved common approval or acceptance. Customarily the Arctic is defined by lines of longitude or latitude, and is designated as anywhere north of 'the Arctic circle'. Yet the Arctic Circle itself is not fixed, but moves depending on the Earth's axial tilt.

Secondly, defining the Arctic in terms of location obscures the way many places north of the Arctic Circle have relatively temperate climates, whilst many places south of this boundary (known technically as ‘subarctic’) have more ‘Arctic-like’ climates, if we define the latter as marked by extreme cold (this is largely due to the activity of the Gulf Stream, which brings warm water from the Gulf of Mexico up along the coast of North America and across the North Atlantic Ocean towards Europe, keeping places like Norway and the island of Svalbard much warmer than other places at similar latitudes in the Arctic). One could also adopt a more ‘topological’ definition of ‘the Arctic’, defining it in terms of relations rather than geographical proximity. Nowadays the focus is more on the Arctic Ocean and its connections to global systems of oceanic and climate circulations rather than say temperature isotherms, lines of latitude and vegetation patterns (Dodds, Nuttall 2015: 151). Political and trade relationships increasingly bind specific sections of the Arctic to spaces and places far south of the Arctic Circle (Depledge 2013; Bennett 2014). The complexities involved in drawing boundaries around the Arctic are further compounded by temperature rises, which mean that the Arctic itself is moving north, with tree lines moving towards the North Pole, and the sea ice edge following suit (Ostreng et al 2013: 7). This is a whole region literally ‘on the move’. The mobility of the sea-ice edge is tied to the mobilities of the oil and gas sector. For the past 30 years, the Arctic has been getting warmer, greener and more accessible to sociotechnical activities shipping, energy extraction and fishing, and is coming to play a more prominent role in various geophysical, geoeconomic and geopolitical processes. Yet climate change is only one of the trajectories helping to forge this ‘new Arctic’. Processes of industrialisation and environmental transformation have been underway since the 1930s. This chapter begins by sketching some key developments in what we might call the ‘AnthropoceneArctic’, before narrowing the focus on the Northern Sea Route.

## Anthropocene Arctic

There are many forms that human inhabitation or colonisation of spaces can take, the literal presence of human bodies being only one of them. Humanity – or a small section of it – might be said to have colonised certain Earthly and atmospheric spaces not through embodied presence but through the spreading of its infrastructures and wastes (Serres 2011). Ironically, despite being one of the least populated parts of the planet, sections of the Arctic are some of the most polluted, and the Arctic as a whole one of the most disproportionately affected by climate change processes. Industrialised humanity, we might say, has colonised or 'terraformed' the Arctic through its wastes. The long-range transport of pollutants from outside the Arctic via ocean currents and atmospheric circulation leads to the traces of pollutants from far-away being found in the atmosphere, in sediments and soil, in snow and ice, in freshwater, birds and animals including humans (Law, Stihl 2007). The main 'paths' by which pollutants find their way to the Arctic are over northern Europe and Asia and then across the Arctic Ocean to northern Canada and Alaska. Pollutants reach the Artic by one major point of entry, the northeast Atlantic. Pollutants from North America are carried by winds or rivers into the Atlantic Ocean and then northward by the Gulf Stream and North Atlantic Drift into the Arctic Ocean, carried under the Arctic ice where they remain protected from sunlight and oxygenation (which would otherwise hasten their chemical decomposition). By this means, much of the far travelled and persistent waste products of the industrialised world are ultimately deposited in Arctic regions.  Each spring a visible reddish-brown mist composed of pollutants from far-away places collect in the springtime at high latitudes, lingering for months. The pollutants are commonly thought to originate mostly from coal-burning in northern mid-latitudes. This 'hybrid object' was first noticed by Arctic explorers in 1750 (Law, Stohl 2007).  Arctic haze is thought to contribute to Arctic warming, and ice-loss (Quinn et al 2008).

Climate change processes disproportionately affect the Arctic. The sea-ice which is the region's defining feature is declining in both volume and extent. The National Oceanic and Atmospheric Association's (NOAA) annual 'Arctic Report Card', a comprehensive review of changes occurring in the North Pole involving some 60 scientists, revealed that air temperatures in the northernmost regions of the globe were, on average, 1.8 degrees Fahrenheit (1 degree Celsius) higher than normal (NOAA 2014: 9).  Warming air temperatures are leading to disappearing summer sea-ice. The extent of this ice has declined 40% since satellite observation began in 1979, and over the same period has thinned considerably, experiencing a decline in volume of 70%. The 2012 September sea ice minimum was 49% below the average of 1979-2000 (figure 4.1), and 18% below the previous minimum in 2007 (NSIDC 2012). The ice made a slight recovery in 2013, but 2015 was the 4th lowest ever recorded extent. This melt is uneven, with high and difficult to predict levels of inter-annual variability, but the overall trajectory is diminishing ice. Sometime this century, scientists believe, the Arctic will be completely ice-free during the summer months. The Arctic warms at a higher rate than lower latitudes due to a feedback effect known as Arctic amplification, (known colloquially as the 'albedo effect'). Sea ice and snow reflect radiation from the sun back into the atmosphere, but when more ice and snow melts, more dark-coloured patches of ocean and earth are exposed, leading already warming surfaces to absorb even more heat (Bridgman, Oliver 2014: 166).

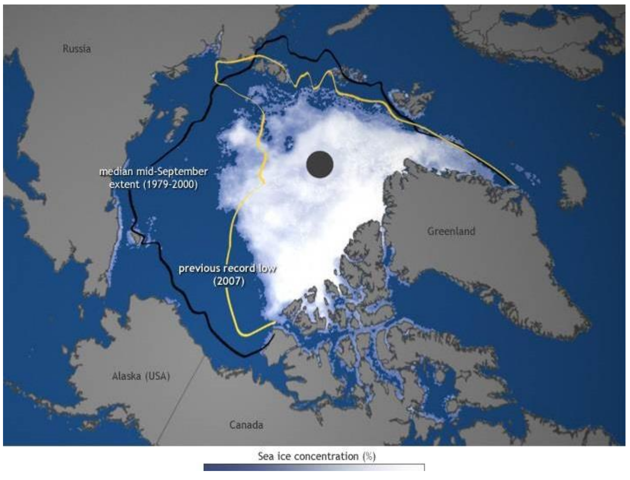

Figure 4.0. Arctic sea ice extent on Sept 16, 2012 (new record low). Black line is historical median extent in mid-Sept and yellow line is previous record low in 2007. Source: NOAA. http://www.arctic.noaa.gov/report12/images/Sea_ice_sep16-final.jpg

Temperature rises, as transduced through the medium of ice, have a range of direct and indirect consequences for wildlife, transportation and resource extraction, both opening and closing possibilities. Perhaps most famously, Polar Bears use floating ice platforms to travel, hunt and look for mates. The Arctic Report Card found the species has experienced a major decline in Hudson Bay, Canada, because of sea-ice loss. The number of females in this region dropped from 1,194 to 806 between the years 1987 and 2011 (NOAA 2014: 60-64). For sociotechnical practices of resource exploitation, particularly oil, gas, minerals and fish, melting ice provides opportunities. Gas is the dominant resource in the Russian Arctic, particularly offshore. As the ice melts, the region is coming to be figured as a ‘new Mediterranean’ (Ostreng et al 2013; Steinberg 2014). Indeed, in a geological sense, the Arctic’s closest relative is the Mediterranean; a sea hemmed-in by land, which not so long ago (in geological) time was a lake. In 2007 satellite images showed that the Northwest Passage along the North American Arctic – searched for by Europeans for hundreds of years - was completely ice-free, prompting speculation regarding future shipping in the region. Economies of anticipation play a key role in this new Arctic. A 2013 study projected that by mid-century regular shipping would be possible directly along the top of the North Pole (Smith, Stephenson 2013). The surprise emergence of the Northwest Passage (NWP) opens a range of possibilities, including providing a route to markets for the resources that currently lie ‘stranded’, an opportunity for cruise tourism, and for the laying of an undersea cable network.

Canadian telecom start-up Arctic Fibre will soon start surveying an underwater route through the NWP that would diversify the globe's undersea fibre optic data network, the infrastructural ‘backbone’ of the internet. Arctic Fibre plan to thread a 10,000-mile internet cable between London and Tokyo via the Northwest Passage, impossible previously as the waters were frozen. Like the development of Arctic sea routes and overland ‘Silk Roads’, the project is intended to build in more redundancy into networks characterised by the prevalence of pressure points, in this case the undersea cable networks that quite literally ‘ground’ the internet (Starosielski 2015). The Arctic Fibre project, much like the Northern Sea Route would avoid the politically volatile Middle East, as the cable would run almost entirely undersea. The $620 million project will also bring internet access to northern Alaska and Canada where data is unreliable and connections intermittent. Arctic Fibre's CEO explained that the project is ‘made possible by climate change’ (cited in Withnall 2014).

Increased tourist flows are a key feature of a globalising Arctic and numbers of these intermittent but constant visitors are predicted to rise (Smith 2010). Recently a luxury cruise operator in the US announced it will offer a “once-in-a-lifetime” trip through the Northwest Passage to experience the major changes now taking place in the Arctic (Withnall 2014). This will be the first ever leisure cruise through the NWP. Up to 1,070 passengers will be taken on the 32-day expedition. The voyage will take place on a 68,000-ton ship accompanied by an escorting ice-breaker and helicopter. *Popular Science* describe the trip as ‘environmental disaster tourism’, quoting research which suggests that the carbon footprint of the vessel, per passenger per mile, is triple that of a Boeing 747 flight. Social media users criticised the trip for giving people the opportunity to “see/help ruin the environment”, “watch the ravages of global warming in person and become a human vulture” and take a “high-carbon-footprint cruise to watch polar bears drown” (Withnall 2014).

The triggers of warming temperatures are largely processes initiated long-ago and far-away – the concentration of greenhouse gases in the atmosphere that might be said to have begun with the emissions of the first carbon into the atmosphere in the 1700s – Watts' steam engine. This is not only the 'globalisation' of pollution (Pollack 2010), but its dispersal through time, with consequences for future generations. However also significant is the depositing of soot or 'black carbon' on Arctic snow and ice, from both proximate and distant sources. Unlike $C0_2$, which persists in the atmosphere for generations, soot is more short-lived, staying in the air for only several days to weeks. Soot gets into the air when fuel, vegetation and firewood are burned, and is now recognised as second only to $C0_2$ as a climate 'forcing agent' (Bond et al 2013). Sea-ice is thought to be a 'tipping element' in global warming, whose loss could induce abrupt or 'runaway' climate changes, although the science is not settled on this point (IPCC 2007). Much of this uncertainty concerns the unpredictable response of the Earth's carbon sinks. Once again the Arctic is crucial here. Currently Siberian permafrost acts as a 'sink', capturing and storing a significant proportion of the carbon emitted on the planet. However, thawing could lead this permafrost to begin releasing rather than absorbing carbon, further accelerating heating processes. Indeed, there is emerging evidence that this process has already begun (Portnov et al 2014).

Like sea-ice, 'permafrost' is a defining characteristic of the Arctic. Permafrost is hidden beneath the surface and even 'less in the public consciousness than sea-ice, glaciers and ice-sheets, but it directly affects human and biological systems' (Marshall 2011: 164). Permafrost can be hundreds of meters thick and tens to hundreds of millennia in age, 'with a geologic intransience' (164). Yet permafrost is also fragile, and liable to melt producing challenges for the construction and maintenance of infrastructure at high latitudes, such as roads, pipelines and buildings. Arctic warming is adding to the challenge. According to an expert in Arctic logistics: 'The permafrost is certainly melting and changing, causing tremendous costs to the governments of the US, Canada and Alaska' (Interview A). Melting permafrost could have remarkable effects, altering ecosystems and damaging infrastructure across Canada, Alaska and Russia. Simulations performed by the Arctic Impact Climate Assessment (ACIA), indicates that over 50% of permafrost could thaw by 2050 and as much as 90% by 2100 (Berner et al 2005: 912). The complexity and costs of building permanent overland roads or rail-beds will increase, as will the construction costs associated with establishing new Arctic harbour infrastructure (Berner et al 2005: 937-940).

The geographies of a melting Arctic then, are profoundly relational. As waters become more navigable, land routes become more unstable. The same sea-ice that has proved such a formidable 'obstacle to navigation' in the words of UNCLOS article 234 (UNCLOS 1982: 136-37, article 234), thwarting efforts by explorers, such as John Franklin, to traverse what Europeans conceived as the 'northwest Passage', also serves as 'connective geographic entity' across which Inuit of the Canadian Arctic hunt, travel and live (Aporta 2011: 7). Although these effects are complex and uneven and involve many uncertainties, melting ice is thought generally to facilitate access for shipping and resource extraction whilst also undermining indigenous forms of life (Dodds, Nuttall 2015). As the former chair of International Circumpolar Council comments 'nowhere else in the world does snow and ice represent transportation, mobility and life for a people. And ice and snow in fact are our highways that bring us to the supermarkets, which is the environment, and links us to each other, to our communities' (Watt-Coutier, cited Goodman 2006: no page). Aporta writes that 'it is remarkable that the same territory [sea-ice] can be perceived and constructed so differently by different actors' (7). Yet this difference in perception and construction, the discursive fluidity of ice, is grounded in the 'shifty' material characteristics of this unique substance. People come to perceive ice in such radically different ways because ice as material substance differs from itself so radically. Rising temperatures have consequences that alter the possibilities for the making of routes, the maintenance of structures, the maintenance of traditional lifestyles, and the extraction of various resources. Emerging are two mirroring but opposed discourses. Alongside ‘catastrophist’ narratives of loss are counter-narratives involving almost utopian expectations regarding the possibilities for unlocking the Arctic’s resource wealth and harnessing the region’s transportation affordances. These inverted narratives are tied to the material properties of ice, its ability to manifest itself in opposing forms.

Arctic temperature rises also have consequences for far-away places. Much as what is happening in the Arctic is a consequence of events occurring far away and initiated long-ago, the Arctic climate affects other parts of the world, and the future. Changes in sea ice affect ocean circulation, which, in turn, affects atmospheric circulation that then affects weather patterns in ‘distant’ places. Research has suggested that warming around the North Pole is leading to the typical path of the jet stream to meander (NOAA 2014: 13).

The relationalities of climate change are embodied in this startling headline from 2013: ‘Melting ice pulling Norway closer to Asia’ (Agence France-Presse: 2013: no page). The town of Kirkenes in northernmost Norway used to be further away from Asia than virtually any other European port but suddenly it seems a lot closer… The reason: Global warming’ (Agence France-Presse 2013: no page). The quote above from a 2013 news article draws our attention to the relationalities of climate change processes, and opens a space for thinking through the relative nature of proximity. From a circumpolar optic northern Europe and north Asia are already neighbours.

Yet whilst the headline gestures to the shifting spatial imaginaries that climate processes might provoke, it also evinces a kind of ‘climate-change determinism’, which makes it appear as though ‘global warming’, all on its own, is drawing Norway and Asia ‘closer’ to one another. This ignores the agentive role of sociotechnical, geopolitical and geoeconomic forces and actors, in the carving of circumpolar sea routes. The passage from shrinking sea-ice to ‘maritime highway’ involves the active intervention of a range of forces, actors and technologies, which together *enact* 'the Northern Sea Route'. The registered and anticipated effects of climate change are intersecting in complex – and uncertain - ways with historical processes. Temperature rises might best be seen as energising already-underway processes of route construction. Efforts to establish a sea lane along Russia's Arctic coast have a long history. The next part of the chapter maps the historical development of 'the Northern Sea Route', before documenting its re-mergence in the 21st century. I embed the NSR within shifting resource and cargo transportation geographies, taking into consideration associated infrastructures, adjacent developments and their consequences for people and places. I jump from site to site in order to gesture to the profoundly relational nature of these developments. There is special focus on the activities of the shipping interests of the Norwegian Tschudi Group, key commercial actors attempting to harness melting sea-ice and exploit the affordances of circumpolarity. I draw on interview material and analyses of company promotional literature.

**Mapping the Northern Sea Route**

> The global economic map is always in a state of 'becoming'; it is always in some sense, 'new'. But it is never finished. Old geographies of production, distribution and consumption are continuously being disrupted and new geographies are continuously being created. The new does not totally obliterate the old. On the contrary… what already exists constitutes the preconditions on which the new develops. Today's global economic map, therefore, is the outcome of a long period of evolution during which the structures and relationships of previous historical periods help to shape the structures and relationships of subsequent periods… earlier economic maps, continue to influence what is happening today (Dicken 2011: 14).

There are many ‘Northern Sea Routes’, indeed the route has gone by at least three names, the Mangazeya Seaway, the Northeast Passage and the Northern Sea Route. Tracing the genealogy of what has come to be known as ‘the Northern Sea Route’ quickly dissolves into a complex and fragmented history involving many parallel but overlapping expeditions and ventures. Interest in finding a route to Asia via the Arctic began in the 1400s, following the blocking of the overland Silk Road to European merchants by the Ottoman Empire in 1453, inducing European states and merchants to seek alternative routes. For the next few hundred years, intense interest in and speculation regarding a passage to ‘Cathay’ (China) via the Arctic emerged amongst the rulers and merchants of Europe (d'Anglure 1984). Europeans concocted the idea of ‘Northeast’ and ‘Northwest’ passages that would lead them directly to the ‘riches of the East’. The first documented search by a European explorer was Englishman Hugh Willoughby’s 1553 voyage in search of the ‘Northeast Passage’, a journey which ended in disaster with Willoughby and his crew perishing, their bodies and his diary discovered by Russian fisherman the following year (Gordon 1986).

In Russia, the idea of a possible seaway connecting the Atlantic and the Pacific was first put forward by the diplomat Gerasimov in 1525. However settlers and traders on the coast of the White Sea, the Pomors, had been exploring parts of the route as early as the 11th century. By the 17th century, Russian traders had established a continuous sea route from Arkhangelsk to the Yamal Peninsula (map). This route was known as the ‘Mangazeya seaway’, after its eastern terminus, the trade depot of Mangazeya (Benson 1992: 56). This route might be seen as an early precursor to the Northern Sea Route. Some sources state that between 1660-1662 the Portuguese captain David Melgueiro sailed across the Northeast Passage travelling all the way from Japan to

Portugal through the Arctic Ocean (Firmino 2014). The year 1660 and the immediately preceding years were the warmest in almost two centuries, putting the temperatures of Arctic waters above normal (Firmino 2014). This was rumoured to be the first complete crossing of the Northeast Passage. The first confirmed complete passage, from west to east, was made by the Finnish-Swedish explorer Adolf Erik Nordenskiöld in 1878. One year before Nordenskiöld's voyage, commercial exploitation of a section of the route started with the so-called Kara expeditions which exported Siberian agricultural produce to northern Europe via the Kara Sea. In 1913 Jonas Lied organized a successful expedition through the Kara Sea to Yenisei, with explorer and scientist Fridtjof Nansen and Siberian industrialist Stephan Vostrotin prominent passengers on-board (as recounted in Nansen 2015). Lied had founded a company known as the Siberian Steamship, Manufacturing and Trading Company (The Siberia Company), with the purpose of exporting and importing goods through the great Siberian rivers and the Kara Sea.

The 1917 October revolution in Russia turned out to be a tipping point for the NSR. The new 'Soviet' authorities initiated hydrographical surveys for the purpose of improving navigation. Geographical observatories were constructed on Novaya Zemlya, Franz Josef Land and the New Siberian islands (Armstrong 2013 [1955]). In 1932, an expedition led by Professor Otto Yulievich Schmidt was the first to sail all the way from Arkhangelsk to the Bering Strait. After trial runs in 1933 and 1934, the Northern Sea Route was officially defined and opened, with commercial exploitation beginning in 1935. The introduction of radio, steamboats, and icebreakers enabled the practical enactment of a 'Northern Sea Route'. Through the combination of ice-breakers and radios, new lines of movement and communications could be carved through the frozen seas. A special governing body Glavsevmorput (Chief Directorate of the Northern Sea Route), which supervised navigation and built Arctic ports was set up in 1932 (Armstrong 2013 [1955]). The route – and the ice-breaker that in many ways was the route - became a literal and metaphorical embodiment of Soviet technoscientific prowess ,appearing for instance on postage stamps (figure 4.1).


Figure 4.1 Postage stamp from 1978 depicting the Arktika Ice-breaker manufactured in 1972. Source: Wikimedia Commons

https://commons.wikimedia.org/wiki/File:1978._.jpg

The creation of the NSR made possible the industrial-scale exploitation of Russia's northern and Far Eastern territories, enabling exploitation of Siberia's plentiful resources including nickel, cobalt, coal and then oil and gas in the latter part of the 20th century. The NSR came to form part of an interconnected rectangular transportation system for the Russian north. The legs of the rectangle consist of, in addition to the passage itself, the big Siberian rivers and the east-west running railways in the south connecting with the rivers thousands of miles from the coast. Ocean-going vessels sail from the port of Igarka. The rivers Ob, Yeninsei, Lena and Kolyma are navigable to the Trans-Siberian railway which is 2270 km south of Siberian coast. The river Lena connects with the Baikul-Amur railway. As has been stated: ‘The NSR and the river system is the primary mode of transportation in this remote part of the world apart from airborne transportation. Nearly all human activity in the Russian Arctic is in some way dependent on the NSR’ (Simonson 1996: 73).

As well as cargo ships travelling the route delivered the equipment and supplies necessary to establish and maintain extraction sites. Everywhere there was a proliferation of lines and channels; overland, through the ice and underground. A 2013 Reuters News report on expanding Russian arctic natural gas shipments to Asia stated that while shipping traffic on the NSR surged in 2012 to around 1 million tons of various kinds of cargoes, "it pales by comparison with the 1987 peak of 6.6 million tons" (Vukmanovic, Koranyi 2013: no page). These resources fuelled the spectacular growth of the Soviet Union throughout the 20th century, and its emergence as a major geopolitical actor. The Soviet Union could not have become a ‘world power’ without this massive input of resources and raw materials from its Arctic and sub-arctic hinterlands (Wood 2012). Not only did Arctic and subarctic resources of hydrocarbons and minerals play an important part in the Soviet economy, but hydrocarbons and mastering and developing ‘the North’ played a corresponding role in Soviet ideology (McCannon 1996; Wilson Rowe 2009; Wood 2012; Bouzarovski, Bassin 2011).

According to Historian of Siberia Alan Wood, Russia and the Soviet Union’s expansion into the North which predates but which reached its furthest expression under the Soviet Union, ‘the territories great natural resources – animal, vegetable and mineral – have been hunted, mined, extracted, despoiled, transported west or exported on world markets to the degradation, detriment and destruction not only of the natural environment but also of the original human inhabitants of the territory’ (Wood 2012:

17) Developments around the area which came to be known as ‘Norilsk’ provide some of the starkest examples of this environmental devastation The emergence of Norilsk and the NSR are inextricably entangled. The mineral resources from Norilsk were some of the first cargos to be moved along the NSR, and indeed continue to be to this day. The settlement of ‘Norilsk’ was founded by Russian geologists in 1921 after they discovered that the region was rich in copper, nickel, and platinum ores. This settlement grew into a city of around 175, 000, and is today one of the five most northerly urban centres in the world (Sassen 2015: 149-158).. It also housed one of the most notorious of the ‘gulag’ forced labour camps established by Stalin. At its peak, around 90, 000 (a third of all prisoners in the Soviet Union) were forced to toil in the mines around Norilsk, where nickel, cobalt and other platinum group metals were extracted and smelted, before being moved by rail to the port of Dudinka, whereupon they would continue along the NSR to Murmansk and then on by rail to European Russia (Bennett 2015). The ‘Norilsk metallurgical complex’ set-up in 1935 has mutated in the 21st century into MMC Norilsk Nickel, Russia’s leading producer of non-ferrous and platinum group metals. The company is now privately-owned, listed on the NASDAQ, and controls a third of the world’s nickel deposits, accounting for some 20 percent of global nickel production. The company also controls ports and a nearby gas field. However, Soviet era infrastructure still forms the backbone of the plant (Sassen 2015: 158). Indeed, Soviet era infrastructure forms the backbone of the entire Eurasian Arctic logistics network, despite utterly transformed political and economic arrangements. It has been estimated that roughly a third of the nickel exported from Norilsk travels to China (Bennett 2015 no page) , where it is used predominantly in the production of steel, which is then used in the construction of (amongst many other things) objects like ships and containers, demonstrating the circular or autopoietic character of industrial production processes. Norislk Nickel own a fleet of custom-built ice-class vessels, built by Finnish-based (but now

Russian-owned) shipyard Aker Arctech, the world's leading manufacturer of ice-breakers. In September-October 2011, an Arctic-class container ship Zapolyarnyy made a demonstration Dudinka-to-Shanghai voyage via the NSR. Bennet writes that whilst the nickel's 'route to ports like Rotterdam and Hamburg is rendered smooth and seamless', residents 'have fewer ways out of the city', with no roads or passenger railways linking them to the outside world, although, on top of its fleet of ice-class vessels Norilsk Nickel own a passenger airline which schedules flights to cities in Turkey, Bulgaria and Egypt. As of writing however, the company are considering selling-off this 'non-core asset'. The carceral legacies of the gulag system, it would appear, continue to be felt in present-day Norilsk.

Today Norilsk is one of the ten most polluted places on earth. According to a report from the Blacksmith Institute 'more than 4 million tons of cadmium, copper, lead, nickel, arsenic, selenium and zinc are released into the air every year' from the heavy metals smelting complex. According to a NASA report, Norilsk produces 1% of the global total of sulphur dioxide ($S0_2$) emissions (NASA 2007). Thus, whilst the Arctic is largely a depository for wastes and pollutants emanating from the more populated regions of the world, the example of Norilsk, ostensibly, stands in stark contrast to this trend. Indeed, it is likely that the carbon emissions of Arctic urban settlements are per head and per capita are high, given their remoteness and distance from areas of production. Goods must travel long distance to get to these cities. Yet the wastes produced through metals and minerals extraction and processing, are a result of resource demands emanating from elsewhere, with the minerals extracted from the region destined for Asia and Europe. Most bizarrely, the soil in the Norilsk region has become so severely polluted as a result of smelting activity that NASA believe it to contain 'economic grades of platinum and palladium' with it now 'feasible to mine the soil' (NASA 2007: no page). Yet the consequences for the residents of Norilsk have been severe, with life expectancy for factory workers in Norilsk thought to be 10 years below the Russian average (Sassen 2014: 157). Bennett writes that: 'Norilsk's environs constitute a landscape that has reached a new nadir of pollution: one that has been so saturated with chemicals and metals that it has transformed against all odds into economically productive land. This is all the more ironic given the pervasive myth of the pristine Arctic' (Bennett 2015: no page). This strange relationship between environmental degradation and economic productivity mirrors that of the 'Arctic paradox', whereby reductions in sea-ice triggered by carbon emissions, are opening further resource and shipping opportunities through the melting ice. Rather than undermine conditions of production environmental degradation appears to be – at least in the short run – laying the ground for further activity.

**'Accumulation by degradation'**

Although Norilsk Nickel continued to use the NSR, the route fell into disrepair following the collapse of the Soviet Union. But in the second decade of the 21st century, melting ice and the anticipated effects of climate change are driving new rounds of industrial development. The 2008 US Geological Survey estimated that 25% of the world's remaining hydrocarbon deposits are thought to lie under the Artic, much of it under sea-ice (US Geological Survey, 2008). Leigh Johnson describes the 'Arctic paradox' as 'accumulation by degradation' which involves 'a concatenation of ecological fixes that are contingent on the self-amplifying feedbacks of the natural world' (Johnson 2010: 834). Melting ice is becoming an economic asset. According to Johnson, states, shipping and carbon capitalist interests are attempting to make environmental changes perform 'work' in production and distribution processes, with a nexus of states and industrial actors 'operating not just on but *through* the environment' (Johnson 2010: 831. Emphasis in original). Radioactive forcing from

GHGs sets in motion a natural thermodynamic feedback mechanism that 'grants access to new factors of production' (831).

Johnson argues that: 'fossil energy and its wastes may *both* operate as subsidies for capital' (835) – recalling the discussion of the 'cross-scale subsidies' discussed in chapter two. This process of accumulation by degradation 'attempts to exploit two scalar disjunctures' (835). The first is the spatial and temporal disconnect between the local scales at which individual fossil fuel combustion events have taken place over the last 150 years, and the global scales at which the resultant GHGs mix in the atmosphere to affect the energy balance of the Earth in the present. A second scalar disjuncture is manifest in the geophysical phenomenon of polar amplification, detailed above, as the rate and magnitude of Arctic regional warming outpaces average warming globally. 'Prospects for accumulation in the region' argues Johnson, 'are thus highly dependent on specific physical properties (of GHGs) and geophysical processes (radiative transfer and the ice-albedo feedback)' (Johnson 2010).

The frictional costs of mobility are lowered because ice is a diminishing physical impediment. The Russian state's plans to develop the NSR into a new 'artery of global trade': and the selling of oil and gas exploration licenses to firms (typically a combination of Russian and Western firms), in the expectation that production will occur at these sites in the near future, are examples of 'anticipatory rent-seeking strategies' in Johnson's terms. In turn, increased energy exploration and extraction bring with them a demand for more infrastructure including ports, ships, storage facilities, pipelines and real-time weather forecasting. The ocean's ice-berg filled waters also pose unique challenges - and 'opportunity niches' (Arthur 2010) - for specialist sectors of the ship construction industry to produce double-hulled ships, tankers and ice-breakers, which can cost millions more than ordinary ships. Melting ice could reduce the extraordinarily intensive capital outlays for deep water exploration and transport of cargo, drilling equipment, and petroleum, and extend the seasonal period in which such operations are feasible (Johnson 2010: 839).

Citigroup identified five Russian companies well positioned to benefit from global warming in the north. Besides Norilsk Nickel, they include Sovcomflot, the state shipping company, and the nation's two largest natural gas companies, Gazprom and Novatek. The fifth is Rosneft, the state oil company that entered a joint venture with Exxon Mobil in 2012 to drill in the Kara Sea, a part of the Russian sector of the Arctic Ocean (Kramer 2011). Asian and Scandinavian firms and states are also strategically positioning themselves to benefit from this expected 'Arctic bonanza'. There are also opportunities for fishing. For the international fishing industry, the target is the so-called Arctic Ocean 'doughnut hole' beyond the 200-mile exclusive economic zones of the coastal nations, which occupies millions of square miles in the ocean's centre. Until 2000, the entire doughnut hole was frozen year round, but now large portions are routinely ice-free in the summer (Kramer 2011).

Russia is retooling a military shipyard called Severodvinsk, outside Arkhangelsk that built the Soviet Union's nuclear submarines, to make ice-capable oil and gas drilling platforms. Contemporary economic activities and developments are then *anchored* in Cold War military activities, demonstrating the reversibility between military and logistic facilities. Indeed, the platform used in the first commercial offshore oil field in the Arctic (discussed further in chapter six) was constructed at Severodvinsk (Bennett 2015). The platform is not connected to any pipeline networks, and thus requires sea transport.  Rickety soviet-era infrastructure provides the backbone for an emerging transnational NSR linking Europe and Asia. Shipping seasons can now last between four and six months, and earlier arrival of spring melt and later autumn freeze are expected to extend this window for even longer (Smith, Stephenson 2013). Routes through the Artic can cut thousands of miles off of traditional transoceanic shipping voyages in the Northern Hemisphere, increasing delivery throughput and decreasing fuel expenditures, and provide a route to extract and deliver the offshore Arctic resources

The Northeast and Northwest Passages have traditionally been sought as short-cuts between Europe and the 'riches of the East'. In contemporary shipping parlance, this is referred to as 'transit shipping'. However today, with increased industrial development and resource extraction activity in the region, the Arctic is increasingly figured as a 'new Mediterranean' (Steinberg 2014), characterised as it is by a similar radial or 'hub-and-spoke' geography and increased industrial activity. This metaphor of the Arctic as a 'new Mediterranean' contrasts with the imagining of the Arctic maritime as a transitional short-cut from Europe to the 'riches of Asia' (or today the cheap manufactures of Asia). Today finding a route to the Arctic, and a route for bringing these riches including oil, gas, fish, ores to 'energy hungry' Asian markets, is coming to rival this imagining of the Arctic as a 'through space'. As one informant said: '…the main use of the Northern Sea Route will be to bring arctic hydrocarbon material to markets' (interview A). Yet in practice these two conceptualisations, one of the Arctic as space moved through, a threshold space on the way to a desired elsewhere and the other as a space of interest in its own right, moved to, from and within ('destinational shipping'), are complementary. Multiple imaginaries can coexist fluidly, in the same way that jurisdictions can overlap in ocean space. In practical terms, the development of shipping networks to bring supplies in and resources out of the Arctic, provides a foundation for the development of transit shipping through the Arctic. Indeed, transit shipping will only increase if there are more ports of call located along the length of the route, if the area turns into a kind of 'Arctic rim' (Smith 2012).

> We have all these resources in the Arctic, and in the Arctic ocean, we have a route to all these energy hungry markets, and its saves 16 or even 20 days to go from Kirkenes or Murmansk, or Yamal, so the Arctic has changed, from being a transport disadvantage to an advantage (interview A).

Thus, emerging is what might be described as an Arctic resource-extraction and cargo mobility nexus, which is primarily Russian controlled but which involves a range of transnational interests, especially from Asia and Scandinavia. Whilst Russian legislation strictly delimits the NSR, defining it as starting in the Bering Strait in the east, and finishing in the Kara Gate Strait of Novaya Zemlya in the west, a more extended ‘functional’ definition might be said to encompass the start point of Murmansk and the end point of Vladivostok. Once we employ functional criteria to define the route, it could be seen as starting in Kirkenes, north Norway, thus giving Norway and Norwegian shipping interests stakes in the NSR’s development. The next section documents the activities of Norwegian shipping interests the Tschudi Group. We need to modify Johnson’s account of ‘accumulation by degradation’ in a few ways: firstly, these activities predate the melting events of 2007 and 2012; and secondly, these activities are not straightforwardly commercial or immediately particularly profitable, although they may raise the profile of the organisations involved and demonstrate experience and competency in markets that may become lucrative in the future. It seems that mastering the route and showing ‘it can be done’ continues to animate present day activities as much as it did during the age of discovery, when adventure, patriotism, exploration and the ‘will-to-connection’ identified by Simmel, were as significant drivers as profits (Craciun 2009).

**Tschudi Group**

In September 2010, an enormous bulk carrier, the MV Nordic Barents transported more than 40, 000 tonnes of iron ore from Kirkenes in Norway along the NSR to the

Chinese port of Ningbo. This was the first ‘non-Russian’ cargo transported by a non-Russian flagged vessel. The ship was chartered by Arctic Bulk Carriers, one of the scores of subsidiaries and affiliates partly or predominantly owned by the Tschudi Group, 21st century heirs we might say, to Lied’s and Nansen’s Siberia Company. The journeys of the Nordic Barents, and other highly publicised journeys, were only ostensibly about selling cargos. They were demonstration journeys designed to showcase the NSR’s viability. ‘Arctic Bulk’, as described on their website is ‘joint venture between the trading company Prominvest SA and Tschudi Arctic Transit AS with the prime purpose of promoting and facilitating dry bulk cargoes, oils, LNG and other shipments including project cargoes [i.e. equipment and supplies to extraction sites] through the Northern Sea Route (NSR)’.  In April 2010, the owner of the Tschudi Group, Felix Tschudi arranged a meeting with Rostamflot, the Murmansk-based company that manages Russia’s fleet of nuclear-powered ice-breakers. Planning of this one journey took more than 5 months. The voyage of the Nordic Barents was a media coup which put the spotlight firmly on the ‘new’ route, or helped to enact the route as ‘new’. As recounted to me by a Tschudi Group shipping agent who played a leading role in orchestrating the journey:

> ….Prominvest [Russian trading company] bought the cargo in Kirkenes as traders, and sold it to China; ok so then we had the cargo; and then I found the ship; and we then did this sort of joint venture, and we know have a ship and we now have a cargo, sold to buyers in china; and then we just did it; yeah that was the first one, now we are opening the NSR (interview C)!
>
> Felix also had some political he also knows the ministry of… the minister of transportation. In Russia. So that was the political side so he talked to him and asked him ‘are you ready to open the Northern Sea Route’?, I mean for international traffic. Because there had been discussions of this going on for a

> few years. This was in 2010. Then he said, you know, er, his minister said, talked to Putin or somebody, probably Putin, erm Putin said yes, we want to show the world, that we er are part of the world [laughs], so Putin said politically 'ok we'll open the Northern Sea Route'. So that's why we did this one, the first one, non-Russian cargo, non-Russian ships, a milestone! (Interview C)

The extract illustrates the overlap between ship owners, charterers and cargo owners that characterises the contemporary shipping business, and the range of state and commercial actors that needed to be mobilised to support the journey. The second notable point is that this journey was as much about breaking geopolitical boundaries – opening-up a formerly closed bastion - as it was about breaking physical or geographical barriers in cargo transportation. Thirdly, the extract demonstrates the embedding of political, economic and infrastructural processes in established interpersonal ties, with Tschudi's links to prominent actors in the Russian state central to lubricating the passage of the cargo.

Tschudi shipping was founded in 1886 by a Swiss émigré to Norway. The 4th generation chairman and owner of the Tschudi Group is Felix H. Tschudi. Tschudi served as Sub-Lieutenant in the Royal Norwegian Navy, before earning a BSc in economics at LSE. Prior to joining the family business in 1989, Tschudi worked for a Swiss banking firm which specialised in trade with the Soviet Union and Warsaw Pact countries, where it is reported he became passionate about developing trade links with the East (Truc 2013: no page). Tschudi shipping specialises in 'East-West trade, including the northern regions of Russia' and the Baltic. They regard themselves leaders in both 'conventional' and 'unconventional' shipping markets. Since the early 90s, the group has had an interest in the northern regions. In a familiar pattern seen throughout the contemporary shipping business, Tschudi now describe themselves as a ‘shipping and logistics group’, rather than just a shipping firm. The range of activities they engage in encompasses a range of logistics ‘solutions’, including ship-to-ship transfers of oil, ocean towage and heavy-lift transportation, and resource extraction. These specialist services are central to contemporary resource extraction and transportation. In practice shipping and resource extraction, especially in the Arctic are difficult to disentangle, as many actors have stakes in several of these activities. The boundaries between firms, between logistics and extraction activities, between states and firms are often little more than nominal. The rise of organisational formats like subsidiaries and joint ventures, which combine and recombine commercial actors and interests, often from across state boundaries (and often for the purposes *of* crossing state boundaries), make it difficult to discern where one set of commercial actors begin and others end.

The Tschudi Group positions themselves as specialists in Arctic transportation ‘solutions’. Tschudi is an umbrella group which encompasses scores of constantly changing and mutating ‘affiliates’, ‘subsidiaries’ and ‘joint ventures’. A google search reveals more than a dozen companies with very similar sounding names, which regularly seem to mutate into new entities. Many of these subsidiaries provide ‘transport solutions’ for cargo to and from Russia, and aim to serve the emerging oil and gas industry in the Russian Arctic. These solutions, of course, help to enact the very ‘problems’ to which they respond. ‘The level of activity within the oil and gas sector is set to increase’, voices the narrator in a 2011 promotional video for one of the Tschudi Group’s ‘wholly-owned subsidiaries’, ‘Tschudi Arctic Transit’, ‘and this will require an increase in the transport systems offered’ (Tschudi Arctic Transit 2010). Given the interdependencies and mutually stimulating relationship between shipping and resource extraction, the availability and provision of specialist Arctic logistics services actively invites the development of Arctic resource projects. Indeed, another piece of promotional literature states: ‘Energy and Mineral resource development in the High North is accelerating… Transport solutions are key to its realization!' (Tschudi 2012: no page). The creation of co-dependent clusters of activity is a salient feature the industrial economy, which Brian Arthur (2010) characterises as composed of open-ended, self-replicating technological networks (see also Simondon 1989), where the emergence of new technologies creates new problems –or 'opportunity niches', driving the development of new technologies and indeed the evolution of the technological ensemble itself. When mediated by the profit motive technological 'solutions' are not just developed in response to pre-existing 'problems' but entire niches are imagined, anticipated and promoted before they exist in reality (i.e. 'needs' are as orchestrated as they are spontaneously evolved).

In 2006 the Tschudi Group became substantial landowners in the town of Kirkenes, a town in Norway, 200 miles north of the Arctic Circle, on the border with Russia. Kirkenes (figure 4.3) is often figured as one of most remote ports on Earth. The town is most likely to be visited as it is the northern terminus of the famous Hurtigruten ferry that travels the length of the Norwegian coast. Yet were the NSR to become a major trade route, this 'remote' port would find itself at the centre of the world. Indeed, from a circumpolar point-of-view it already is. This port has already been of enormous geopolitical significance. The town was invaded by the Nazis during World War Two, and was a key node as the Luftwaffe launched their bombing raids on the UK from Kirkenes. The Soviet Union liberated the town from Nazi occupation in 1944. The area was one of only two land borders between NATO and the Soviet Union during the Cold War. Yet relations with Russian neighbours have always been cordial, and indeed 10 percent of the town's population are Russian. According to a local resident 'the people of Kirkenes have not forgotten that it was the Soviets that came to liberate them from the Nazis' (cited in Truc 2013). From 2012, residents travelling within 30 miles of the border were allowed to do so without visas, although 'Cold War 2.0' has ended this.


Figure 4.3. The port of Kirkenes. Credit: S. Savitzky.

Like the city of Norilsk, the settlement was built around a local mine, Sydvaranger. The mine became unprofitable during the 1980s, but the Norwegian government were keen to keep the northern borderlands populated, especially given the proximity of the Soviet Union, and so subsidised the mine. The case of Sydvaranger illustrates the ways in which infrastructures are often entangled in social dynamics that are autonomous from their technical functions (Larkin 2013). With the end of the Cold War, the Norwegian government stopped subsidising the mine, and it closed in 1997, where after the town’s population declined to about 2, 000 people. Felix Tschudi bought-up the entire mining operation in 2006, including the ore processing plant, adjoining lands and port facilities for 102 million Krone (about £8 million), via an Australian firm he had specially set up called Northern Iron Ltd. At the time, much iron ore was being brought by traders and sold to Chinese steel mills, where it was used according to an interviewee in ‘everything from railways, to bridges, to cars, to containers’ (interview D). The mine restarted production in 2009. The mine and its resources are relatively low-value and low profitability, but the mine’s strategic location is key. Indeed, it was ore from Sydvaranger that travelled along the NSR to China on board the *Nordic Barents* in 2010. This was a relatively low value cargo, and could have easily travelled, as it typically does by rail to more southerly ports and on to China through the Suez Canal. But the mine and the cargo were assets whose chief value did not lie in their own profitability, but in the way they could be used as points to 'anchor' into the NSR.

Tschudi admits in an interview that he 'wasn't interested in the mine… I brought this company primarily for its port facilities and its potential as a hub for transport and logistics' (cited in Truc 2013). Thus was born 'Kila', the Kirkenes Industrial Logistics Area project. The facilities – still under development at the time of writing – are intended to serve as 'an integrated hub for shipping and logistics, to serve the future needs of the oil, gas and mining industries in the region' (Tschudi Arctic promotional video 2011). The development and the mine, has reportedly had a range of social and ecological consequences. Ore residues and wastes, containing chemical products, from the mine, transported by an underground tunnel, is piled-up in the fjord. 'The fjord's entire basin is dead' according to a resident that heads up an association which opposes the dumping of waste (cited in Truc 2013). Additionally, local reindeer breeders say the logistics projects being developed by Tschudi and an adjacent oil terminal being developed on the other side of the Fjord by Norwegian petrochemicals firm Stolt-Nielsen, are threatening their livelihood, in so far as they obstruct access to the salts and minerals embedded in coastal lands that reindeer require in order to remain healthy (Truc 2013).

**New Arctic nodes and routes**

Reindeer are the crucial resource for the nomadic and semi-nomadic peoples that inhabit the Eurasian Arctic, serving simultaneously as food, transport and clothing. Both the Saami peoples mostly concentrated in Finnmark (the borderlands between

Norway, Finland and Russia), and the Nenets mostly concentrated in Siberia, are dependent on reindeer (see here anthropological work, e.g. Rees et al 2007; Stammler 2007; Anderson 2009; Vietskby 2011). The nomadic spatial practices of the Nenets at times come into conflict with the global production networks of the extractive industries which increasingly populate the 'Anthropocene Arctic'. Both forms of spatial occupation presuppose regular or intermittent long-distance travel, but whist the routes of reindeer herdsman are embodied in reindeer and people (although increasingly augmented through technologies like snowmobiles and GPS), extractive industry paths require massive 'sunk' infrastructures like pipelines, ports, railroads and highways (see chapter two). The so-called 'Yamal megaproject', a huge oil and gas field in northwest Siberia provides one such site of conflict between reindeer herdsmen and the extractive industries. This project consists of numerous onshore oil and gas fields in the Yamal in north western Siberia. The fields consist of 16 trillion cubic meters (tcm) of explored and provisionally evaluated gas reserves, and an estimated 291.8 million tonnes of oil reserves. The Yamal Megaproject is transnational consortium developed by Gazprom, but also involving French firm Total and the Chinese National Petroleum Corporation (Gazprom no date; Sharples 2016). The project is described as 'a complex of drilling towers, electrical pylons, gas condensation facilities, water containers, gas wells, worker dormitories, administrative buildings, piles of shipping containers, pipelines, countless bits of other infrastructure' (Hammer 2010: no page). As a Gazprom press office states in an interview, 'it's like landing in a space station isn't it?' (Gazprom press officer, quoted in Hammer 2010: no page). Nenets herdsmen are now forced to divert their herds from routes they've used for more than a thousand years, and forced to make long detours around pipelines. Ancient yet intangible human/reindeer migration routes find themselves blocked by the oil and gas industry's obdurate yet in some ways ephemeral steel paths, which are destined to become relics once they have extracted all they can from the fields. The gravel and tarmac roads used to bring supplies to the fields interfere with the sleds the Nenets use as their main form of transportation, while glass from smashed Vodka bottles and other detritus discarded by Russian extraction industry workers present significant dangers to moving groups of reindeer (as documented in Hammer 2010: no page).

Adjacent to Gazprom's project is the Yamal LNG project. The Yamal peninsula is estimated to hold the largest gas reserves in the world. The region, however, has some of the most hazardous working conditions. The land is boggy, making drilling operations a challenge and in the winter season, daylight is available only for a short period, meaning operations need to be carried out hastily. The area is also very remote, with workforce having to be air-lifted from outside. The nearest potential market is also located 3,000km away (Hydrocarbons-technology.com 2012: no page). Despite these challenges, several companies are investing in the region to recover the large gas reserves. When fully-operational, the Yamal LNG plant is expected to to produce an annual 16.5 million tons of LNG (Lund et al 2015: 115). The project is being developed by Novatek, French energy firm Total SA, and in August 2015 the Chinese government's Silk Road fund acquired a 9% share in the project, signalling a massive broadening of the new silk road, which aims to fund infrastructure and foster ties improving connectivity between the Chinese economy and the rest of the world. Chairman of the Management Board of Novatek, Leonid V. Mikhelson stated "We welcome SRF's entrance into the Yamal LNG project as another step forward in the mutually beneficial cooperation with our Chinese partners in the development of gas projects in the Russian arctic region" (cited in Businesswire 2015: no page).

Novatek and Total are developing another project named Shtokman in the same region. Another project is Sakhalin-2, where Gazprom has partnered with Shell, Mitsubishi and Mitsui (Bradshaw 2010). LNG could reach Japan in 3 days via the

NSR. Asian countries are not only interested in purchasing LNG. They also seek to supply the projects with their home-built ships and offshore equipment. South Korea, China and Japan are also ship-building powerhouses. Daewoo recently won a contract to provide 16 ice-class LNG tankers for the Yamal project, ‘thus furthering Seoul’s Arctic reach’ (Bennet 2014: 2). Energy might be seen as strengthening ties between Asian and Arctic states.

A major facility known as the Sabetta port is being developed, which – if completed – will function as a ‘gateway’ linking the Yamal LNG project to Asia and Europe via the Northern Sea Route. The Port of Sabetta is a new seaport under construction on the western shore of the Ob Bay in the Yamal Peninsula of Russia. The port was initially being developed by privately owned Russian gas company Novatek, in partnership with the Russian state. The port involves the construction of an integrated onshore LNG facility. The construction of the port started in 2012 and is scheduled for completion in 2016 (Lund et al 117). Ship-Technology.com state that Sabetta will ‘lay the foundation for further development of hydrocarbon fields located in the Yamal Peninsula and the Gulf of Ob’ (ship-technology.com 2013: no page). The port will cover an area of 59 hectares. The project involves the construction of a 50km sea channel, a 6km long and 420m long approach channel, and berths for construction materials cargo as well as gas tankers. A commemorative capsule at the construction site of the new port near the village of Sabetta reads: ‘ "Creation of a new port will enable development of the Russian icebreaker fleet and rebirth of the Northern Sea Route. We are confident that today is the beginning of the future development of the entire Arctic region" (Arctic-info.com 2012: no page).

Similar to the Tschudi Group’s Kila project, the plan is to turn the seaport into an integrated complex that can be used not only for the export of LNG, but also grain from Siberia, metals from the Ural mountains, coal from the Kuzbass area, and oil products from the Russian Far East. Such integrated port complexes – Rotterdam is the chief example - resemble manufactured consumer objects, scaled-up in size, in the way they aggregate and amalgamate disparate resources from disparate locations, and emerge from flows of raw materials. Whilst such complexes would 'anchor' Arctic shipping routes, key obstacles to their development at the moment are a lack of viable land routes that would connect them to the outside, through which cargos could be transported to the ports. The Kila project has stalled, in part, as the Norwegian government has not built the necessary road infrastructure which would link the facilities. The Tschudi Group will now embark on the construction of 3.5km highway themselves (Trellevik 2014: no page). Thus, the carving of the NSR involves, presupposes and produces the carving of many other infrastructures and 'lines of transport', dispersed across a range of sights. The shadow or footprint cast by the NSR covers thousands of miles of land and sea spaces as infrastructures plug-into one another and from related complexes which impact on other circulations, such as animal migration paths and the indigenous livelihoods built around them. Conversely, the absence of relatively small-scale infrastructural links (such as the road linking Kila to the adjacent port of Kirkenes), can have implications that reverberate across a wider territory, affecting the development, viability and attractiveness of the NSR as a whole.

**Conclusion**

The developments documented are highly precarious however. Even with melting ice, the costs associated with extracting resources from the Arctic are still enormous. Seasonal operations make it difficult to recuperate the costs from investment in ice-class vessels, which can only be used for a few months of the year, and that are much more expensive than regular sea-going vessels. Arctic pursuits require greater outlays of capital to fund long-term infrastructure and exploration projects, and the costs to insure these ventures are especially high due to the high risk of environmental disaster and damage to equipment. ‘A tremendous number of factors must coalesce, including physical environments, successful energy exploration and extraction, supportive governments, and permissive climate and/or carbon regimes’ (Johnson 2010: 827). These may be short-lived due to the ‘dynamical emergent properties that are likely to materialize in the physical climate system’ (Johnson 2010: 829). In 2014 eight sinkholes were discovered within a 10 km radius from the Yamal Megaproject’s Bovanenkovo gas field. The appearance of these sinkholes is believed by Russian researchers to have been caused by methane released due to permafrost thawing. According to researchers at Norway's Centre for Arctic Gas Hydrate (CAGE), the Siberian permafrost which extends to the seabed of the Kara Sea, a section of the Arctic Ocean between the Yamal Peninsula and Novaya Zemlya, is thawing. According to a CAGE researcher: ‘The thawing of permafrost on the ocean floor is an ongoing process, likely to be exaggerated by the global warming of the world´s oceans’ (cited Science Daily 2014: no page; Portnov et al 2014). And barely a month after Obama gave the go-ahead for exploration in Alaska to commence, Shell abandoned their operations citing ‘the high costs associated with the project, and the challenging and unpredictable federal regulatory environment in offshore Alaska” (Van Beurden, cited Macalister 2015: no page).

I have documented a range of geophysical, geopolitical and geoeconomic processes that are leading to the Arctic becoming more entangled with the rest of the world. I started by outlining some general characteristics of this new Arctic, before considering the historical development of ‘the Northern Sea Route’. I then explored the ways in which melting ice is being made to perform work for shipping and carbon capitalist interests, examining the operations of the Tschudi Group, before considering some of the key resource sites and port complexes which might be said to form part of the NSR’s ‘environment’. The next chapter examines Arctic shipping infrastructures more closely, and the range of ‘strategies of insulation’ that have developed to protect ships and their cargos moving through these turbulent elemental spaces.

## Chapter five: Securing flows

### Introduction: Insulation and isolation

The previous chapter examined a 'new' Arctic within which a 'new' Northern Sea Route has emerged. I traced the historical trajectory of what has come to be known as the 'Northern Sea Route'. I examined some of the main political and economic activities which are effectively carving out the route in the 21st century, situating the re-emerging NSR in a broader resource landscape, and documenting the development of key Russian Arctic extraction nodes, processing sites and ports, in which emerging shipping networks are becoming 'moored'. This chapter examines more closely the (im)mobilities of Arctic shipping, the way the construction of passages, routes and connections entail many forms of insulation or containment. In order for certain things to move, others must be prevented from doing so: which is 'a matter of organizing circulation, eliminating its dangerous elements, making a division between good and bad circulation, and maximizing the good circulation by diminishing the bad' (Foucault 2007: 18). In particular, the unruly mobilities of sea-ice must be prevented from impinging on the circulation of ships and cargos. Especially in a turbulent and shifting environment, many forms of insulation are required to safeguard the smooth passage of cargos. Yet due largely to the relatively remote character of the region, many necessary forms of insulation are lacking, with many infrastructural and regulatory absences and discontinuities both leaving vessels, seafarers and cargos exposed to risks from a hostile environment, and simultaneously leaving a 'delicate' environment potentially exposed to the various seeps and spills associated with shipping activity. The 'will-to-connection' starkly embodied in the Northern Sea Route actually entails stopping things from moving as much as it involves making things move. Firstly, unpredictable circulations must be prevented from impinging on the movement of vessels and their cargos. Secondly, potentially unruly cargos – especially oil – must be prevented from flowing beyond control and entering into wider ecologies. Thirdly, strategies of insulation also involve preventing entities, such as invasive species, from circulating along with cargos.

Langewiesche (2005) calls modern cargo ships ‘the most independent objects on earth’. This ‘independence’ however is predicated on many forms of dependence, including on satellite networks and search and rescue (SAR) coverage, which provide a ‘reliable envelope of mobility’ (Law 1997: no page) within which ships and cargo can move with a degree of safety through hazardous ocean space. Such supporting infrastructure is nowhere more necessary than in the Arctic. The range of spaces and infrastructures that need to be harnessed in order to support relatively reliable and ‘safe’ movement through the seas are many, involving adjacent ports, earth-orbiting satellites and networks of ice-observation stations. A massive ice surveillance apparatus must be enlisted in order to support cargo shipping through the Arctic, especially as scheduling and insurance considerations have come to take on more prominence in cargo shipping. Knowing the weather and the future state of the sea is especially crucial for shipping in Polar waters (Ostreng et al 2013: 199).

**Insulating and anchoring cargo flows**

To illustrate my argument I borrow the terms ‘strategies of insulation’ and ‘strategies of interconnection’ from Starosielski’s ‘The Undersea Network’ (2015). In her account of the undersea cable networks which provide the physical ‘backbone’ of the internet, but which remain largely invisible in studies of digital media, Starosielski documents the ways in which, if they are to be successful, undersea cable projects must both find ways of linking-in to existing processes, which she calls ‘strategies of interconnection’, and also employ methods for protecting cables from external turbulence, including sources of social and environmental disruption, which she calls ‘strategies of insulation’. She defines strategies of interconnection as ‘the leveraging of existing circulations to support new networks (2015: 19-20), and ‘strategies of insulation' as 'modes of spatial organisation that are established to transform potentially turbulent ecologies into friction free surfaces… (2015: 17). Whilst the terms anchoring and insulating appear to designate opposing or contrary strategies, they are in fact complementary, as connecting to certain things enables disconnecting from others (2015: 15-17).

Starosielski's account of the undersea cable network is highly apposite to this study. Her characterisation of this network as 'semi-centralised' resonates with my account of the contemporary shipping system (see chapter three), as does her emphasis on the gravity exerted by existing routes and centralising forces in a world supposedly characterised by distributed or 'point-to-point' processes. The metaphor of 'insulation' is especially pertinent in sub-zero environments, where protecting cargo flows often involves literal insulation from the ravages of the cold. The metaphor of insulation can also be widened to encompass the provision of repair, maintenance and SAR services. These insulate by providing security in case of unexpected events, such as accidents and malfunctions. These function as a kind of insurance, contingency plans in case things go wrong. Insulation is not limited to physical infrastructure; the provision of financial insurance can be considered another strategy of insulation, which provides some form of protection in case things go wrong. Insurance presupposes a 'sea of data' that accompanies physical movement, as discussed in chapter three Insurance premiums are dependent ultimately on the availability or not of other forms of infrastructural 'coverage' (Hjalmarsson 2015: chapter eleven).

These ideas resonate with Urry's (2007) concept of the paradoxical entwining of autonomy and dependence. Urry argues that, for instance, highly personalised social networks are predicated on persons' dependence on various physical-digital systems such as automobility and the internet. People are able to carve out highly personalised time-space 'tunnels' because collective systems are emplaced which enable such mobilities and connections (Urry 2007: 3-17. These patterns of autonomy through dependence apply to ships and the shipping system, which whilst they are often described as ‘floating islands’ (i.e. Langewiesche 2004) due to their autonomy from nation states as well as their seeming physical independence, are moored in infrastructures even as they move through the seas. However, such mooring is only ever partial, especially at sea. The high seas’ distances from concentrations of people leave vessels and cargo vulnerable, even as these distances also provide a veil of secrecy which itself can provide insulation to vessel and cargo owners from the burdens and disruptions of state regulation and oversight (Urry 2014: chapter nine).

A key driver behind Arctic cargo shipping is the need to insulate cargo flows from the turbulence associated with chokepoints and piracy that characterise the southern sea routes (see chapter three). Suez, the Strait of Hormuz and the Strait of Malacca are increasingly congested and frictional passages. These shipping routes are central to bringing resources in to production areas, and bringing products and components from Asia. As we saw in chapter three, new routes are being developed in response to congestion and in anticipation of blockages along these key arteries, one of which is the NSR, which is thought to be becoming more accessible due to climate change processes. However, moving cargo through the Arctic introduces new forms of turbulence. I next outline some features of this turbulent maritime environment, before considering the strategies that have been developed in order to insulate ships and cargos from such turbulence.

**Arctic turbulence**

The Arctic is difficult to domesticate. It is a shifting environment. The access it yields is uneven, and intermittent, cut into by the advance of winter and the unpredictable rhythms of sea-ice and the elements.  Sea-Ice, mobile ice floes, sub-zero temperatures, especially hazardous storms known as ‘Polar Lows’, fog and poor visibility all increase the risks of accidents and damage to the local environment (Ostreng et al 2013: 147-172). The history of quests to 'find' both the Northeast and Northwest Passages is littered with failed voyages, costing the lives of many (Geiger, Beattie 2004: chapter four). These problems are compounded by the remoteness of the spaces in question. This a problem that all vessels that make use of the deep seas face, the distances from sources of sustenance and security. However, proximity to the 'warmth' of concentrations of people also poses problems; ships must often pass through social and geopolitical 'hotspots' which threaten to disrupt shipping. Proximity to concentrations of people simultaneously brings hazards and benefits. With people come politics, and with politics come possible disruptions to the operations of cargo mobilities and resource extraction. People can both come to one's assistance, but people are often also a source of threat. Remoteness brings both benefits and hazards. The Arctic's remoteness tends to be figured as a problem, i.e. the distances from sources of repair and maintenance are routinely invoked as obstacles preventing the growth of the route, yet it is precisely this distance from people, from geopolitical 'hotspots' and pirates, that along with the shorter distances, is a major attraction of the Arctic for shipping in the first place. We have seen how ice, storms, sub-zero temperatures, fog and poor visibility combine to create a particularly 'turbulent ecology' (Starosielski 2015: chapter one) which threatens to disrupt the circulation of ships and cargos. I now describe the key innovations that have evolved as a means of insulating ships from this volatile environment.

## Insulation

### Ice-breakers

Key to the enactment of Arctic shipping routes was the emergence and subsequent development of ships capable of breaking through ice. Icebreakers provide the most significant forms of insulation to vessels and cargos in ice-covered waters around the world. Icebreakers are special-purpose ships designed to navigate ice-covered waters, and clear paths for cargo ships to follow. Along the NSR, ice-breakers provide what is often the only SAR coverage in what are highly ‘remote’ areas. Innovation in ice-breaking began over 100 years ago and has developed considerably since the 1960s. Even in the earliest days of polar exploration, ice-strengthened ships were used (Johnson 2014: 1-13). The first ice-breakers were wooden vessels reinforced with double planking to the hull and strengthening inside the ship. Bands of iron were wrapped around the outside, protecting the ship in case it was ‘nipped’ by the ice, which occurs when ice floes around a ship are pushed against the ship, trapping it as if in a vice (Riska 2010). This vice-like action is caused by the force of winds and tides on ice formations. Although such wind and tidal forces may be exerted many miles away, sea-ice transduces the force (Bridgman, Oliver 2014: 151-161).

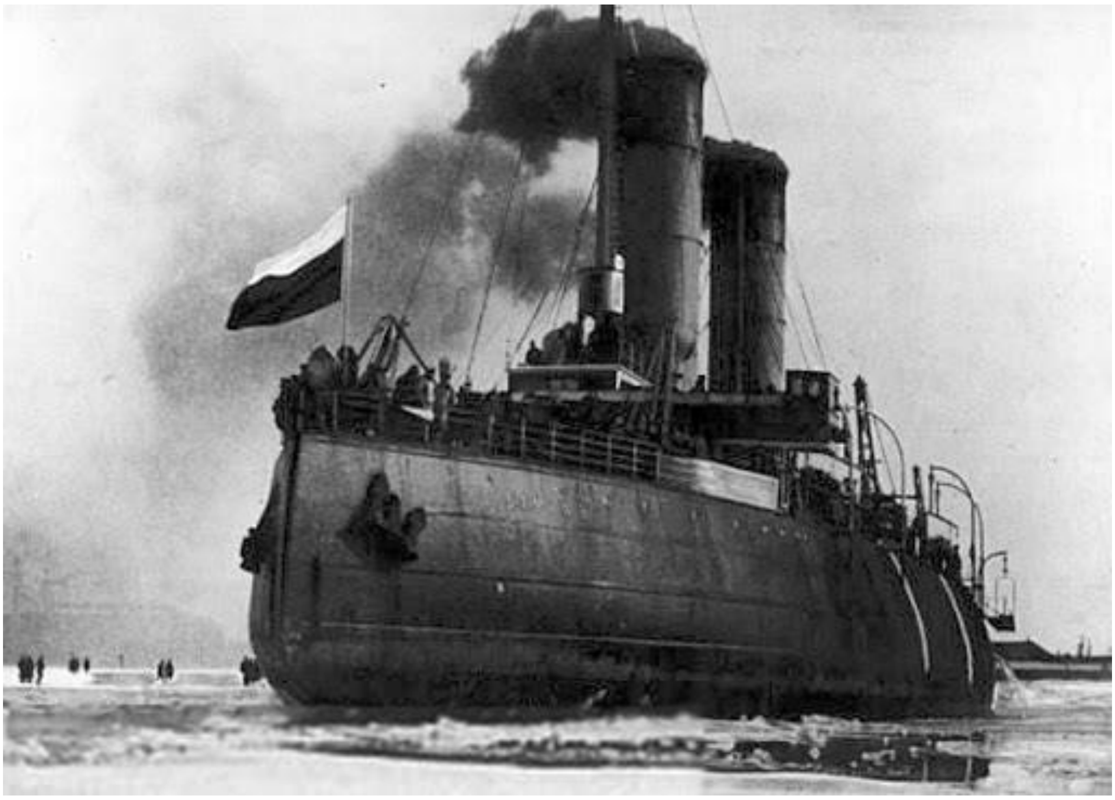

Figure 5.0. Russian ice-breaker *Yemark*, 1899. Source: Wikimedia Commons https://zh.wikipedia.org/wiki/File:Yermak_icebreaker.jpg

Innovation in ice-breaking is dependent on the amount of energy that can be deployed in order to break through ice. The first major innovation was harnessing the power of coal in the form of the first steam-powered ice-breakers (figure 5.0). The Russian ice-breaker *Pilot* made in 1864 was an important predecessor of modern icebreakers (Riska 2010: 3-5). The vessel was modelled on the ship designs of the Pomors who had been navigating sections of what has come to be known as 'the NSR' for centuries (Benson 1992: 54-56)). The world's first diesel-electric icebreaker was the 4,330-ton Swedish icebreaker *Ymer* built in 1933. The most powerful ice-breakers in the world are nuclear-fuelled. The world's first nuclear-powered surface ship and the first nuclear-powered civilian vessel, *NS Lenin*, was launched in 1957 and entered operation in 1959, before being officially decommissioned in 1989 (Mikhaylovich 2009). It has been turned into an ice-breaker museum in Murmansk. The development and use of nuclear-powered ice-breakers presupposes or is anchored in a system of nuclear power production, distribution and disposal. Disposal of the wastes that are produced through nuclear reaction is especially problematic, with these wastes some of the most dangerous and long-lasting known to humanity. The intensity of the force needed to break through ice produces involves the production of waste by-products of a similar intensity, and which themselves break through spatial and temporal boundaries. Providing insulation for vessels and cargos moving through frozen waters entails the production of turbulent conditions for many other circulations, as radioactive materials could seep into biological and human ecologies, especially via fishing. According to the Norwegian Radiation Protection Authorities (NRPA), the Soviet Union dumped 19 ships containing radioactive waste; 14 nuclear reactors and 735 other pieces of radioactively contaminated heavy machinery, 17,000 containers of radioactive waste, and three nuclear submarines (Bender 2015). The Anthropocene Arctic is a nuclear Arctic, with nuclear powered machines and their wastes in circulation and stasis through the frozen seas

Other than the sheer power that can be harnessed, innovations in ice-breaking include developments in ship propulsion and manoeuvrability. For instance, the recently devised ‘azimuth’ thruster allows for movement in any horizontal direction. The azimuth thruster is typically included in ‘double acting’ ships, which are vessels that can sail forward in open waters but turn around and proceed astern in heavy ice-conditions (Juurmaa et al 2001: 722). Russia currently operates all existing and functioning nuclear-powered icebreakers. The transit fees that Russia charge for moving through the NSR are for ice-breaker escorts, which Russian legislation stipulates is obligatory for all traffic using the NSR. These ice-breakers (figure 5.2) perform other ‘insulating’ roles as well as carving a literal route for ships (indeed ice-breaker manufacturers are increasingly referring to ice-breakers as ‘ice management vessels’. See McGwin 2015). In many ways, ice-breakers *are* the NSR. The state firm that own and manage the fleet are Atomflot (or sometimes known as Rosatomflot), which employ around 2, 000 people. Tourist cruises account for around 7% of the company’s revenues.  According to one interviewee, this fleet of ice-breakers form what he describes as a ‘floating infrastructure’:

Q What would you say are the main impediments to increased shipping along the Northern Sea Route?

> The chief barriers are the lack of infrastructure, and the remoteness and the lack of support infrastructure – at the moment. So, so… the best infrastructure that we have at the moment are the Russian ice-breakers. This is very important due to lack of any other kind of infrastructure along the route. If there is a mishap, it could take a few days for rescue to arrive. This is why the ice-breakers are so necessary. They are like a ‘floating infrastructure’ (interview A).

The term is useful as it gestures to the ways in which Russia's fleet of ice breakers, whilst key to the NSR are also relatively autonomous from it, and function as part of other systems, i.e. they are used to break the ice during the winter seasons along sections of the great Siberian rivers, like the river Ob. In order for cargo and vessel owners to prevent the turbulent mobilities of sea-ice from impinging upon their operations, it becomes necessary to enlist the services of ice-breakers, which cost some 400, 000 US dollars to hire (Truc 2013: no page). Ultimately the material basis of legal sovereignty over Arctic routes and resources rest on this 'floating infrastructure' (which is also symbolically pregnant). Through this fleet of ice-breakers Russia *enact* sovereignty over the NSR. The enlistment of Russian ice-breakers by transnational shipping and carbon capitalist interests entails the de facto reassertion and reproduction of Russian sovereignty over the NSR.  Thus, providing insulation to cargo, in so far as it mobilises these ice-breakers, simultaneously involves the reassertion of Russian sovereignty over the passage, to gesture to the complexities of sovereignty and transit in the Russian Arctic (discussed in more detail in the next chapter).


Figure 5.2. Atomflot ice-breaker *Yamal* escorts a convoy of vessels through the NSR. Source: Wikimiedia Commons

Carving the NSR thus involves increasing ice-breaking capacity, which can be taken to mean both enhancing the operational capabilities of ice-breakers, and increasing the numbers of ice-breakers in operation. Russia has embarked on what it calls 'Project 22220', the building of 10 new ice-breakers in anticipation of increased activity along the NSR (Moskvitch 2012). The lead ship is named Arktika (LK-60) and is being built at a St Petersburg shipyard. It will be the world's largest icebreaker and fitted with a new type of nuclear power reactor, called RITM-200. The icebreaker will be capable of displacing some 33,540 tons of ice and will measure 173.3 meters long by 34 meters wide, and feature a double-draught design which will allow operation in both the Arctic Seas and the estuaries of Polar rivers. Delivery of the vessels is expected by 2020. The vessels will primarily be used to escort tankers carrying hydrocarbons from deposits located on the Yamal and Gydan Peninsulas, as well the Kara Sea shelf, to markets in in the Atlantic and Pacific (Moskvitch 2012). Along with the ‘hardware’ of ice-breakers, insulation from ice involves the ‘wetware’ of embodied human agents in the form of ‘ice-advisors’ or ‘ice-pilots’, which are often also a mandatory requirement for any vessel transiting the NSR.

**Ice-pilots**

As well as hardware infrastructure, the tacit competencies embodied in a relatively few number of human agents with experience in navigating the Arctic, are another ‘element’ which provides insulation to vessels and their cargos. Ice-pilots or ice advisors along the NSR are usually provided by state-owned Atomflot, or are accredited by the Northern Sea Route administration, established in 2012 and located in Moscow. According to one of my interviewees: ‘these are former active masters with at least six months experience specifically in the Arctic seas, the Kara sea, Siberian sea, Laptev sea’ (Interview B). Whilst other seas are icy, the specific characteristics of the maritime Arctic make a difference as ‘the Baltic sea contains only ‘one year’ ice, but in the Arctic, you may encounter ice ridges, floating ice bergs, moving fields of ice, and the situation is changing [sic] very quickly in the Arctic, even if we have very strong vessels it’s [sic] still a danger’ (Interview B). The NSR administration decides whether a vessel requires the presence of an ice-pilot or advisor, depending ‘on the type of vessel, on the risk of proceeding without having on the bridge a really experienced person, and this decision is taken… based on info provided by ship, it could be that there is an obligatory requirement’ (Interview B). A captain of a vessel that made one of the ‘demonstration’ voyages through the NSR recounted that specialist ice-advisors: ‘can tell from the colour of the ice whether its old or new [and thus whether it needs to be avoided]… to me I can’t tell the difference’ (Interview D). But it was also, according to the captain, the accompanying ice-breaker’s powerful night time reflectors which enabled the ice-advisor to discern the colour of the ice, demonstrating the specific ways in which human and machine elements come together in practices of routing through Arctic waters. The presence of ice-advisors can also create potential friction however:

> … you have to follow his [ice-advisors] advice because he is in contact with ice-stations at all times, he knows the situation with the ice, where is the ice, because in that part of the world the weather forecast is not so much covered…. but he is speaking in Russian you do notunderstand what he is saying…. Sometimes pilot talk with land station, sometime he might be calling his wife, I have no idea (Interview D)

Indeed, the problem of insuring interoperability amongst ships' human element is challenge in a globalised industry that draws its personnel from all regions of the world (George 2013: 15-30). The captain made a recommendation to the firm following the journey that crews be staffed by at least two Russian speaking members on future journeys through the NSR. As well as ice-breakers and ice-pilots, the presence of ice is driving the development of novel kinds of weather forecasting, specifically concerned with the movements of sea-ice, techniques which are associated with climate change modelling, and predicting the future state of ocean-space

**Ice-forecasting**

If timely information regarding weather is crucial for shipping in general, this is even more so for shipping activity in the Polar Regions, where storms, fog and ice especially present major obstacles to reliable, safe and timely cargo distribution and resource extraction operations. The growth of shipping and offshore activity in icy regions has opened-up an 'opportunity niche' (Arthur 2010) for innovation in ocean weather-forecasting, resulting in the rapidly developing field of 'ice-forecasting', an applied interdisciplinary science underpinned by advances in remote sensing and numerical modelling (Eicken 2013; Day et al 2014). Ice-forecasting attempts to anticipate and map the mobilities of sea-ice, its patterns of melting and freezing, the location of the ice-edge, as well as the location and trajectory of moving ice-floes, providing another important source of insulation to vessels transiting the NSR, and other icy waters and shipping lanes around the world. Monitoring and moving through the Arctic are inextricably entangled; the provision of forecasts to vessels and off-shore operations is seen as crucial, for planning of optimal sailing routes for ice-breakers and other vessels. A prominent meteorologist explained the history of the emergent field of ice-forecasting:

> When satellites came out at the end of the 60s, we started to do ice analysis; the first reason for my institute was to be able to model the location of the ice-edge, so where is ice and where does open water begin, as it is important [in climate modelling]; but then as a 'spinoff' it became very useful for mariners.. There have always been requirements from mariners to have ice-forecasts for fishing industry, for tourism, for surveillance like the coast guard… as satellite instruments have improved, so we can do it [predict the movement of ice and the location of the ice-edge] in more detail (interview F).

He went on to explain the significance of what he called 'new ice patterns' for shipping activities:

> … north of Svalbard, last few winters it has been open water… but they [fishing trawlers] can go there in winter that they didn't used to be able to. But it's also dangerous, and requires real-time info and forecasts, they can be trapped in the ice; we feel the expectations of better info. As these places open up, there is no tradition of sailing there, you can't listen to your father, he wasn't there 20 or 40 years ago (interview F).

Ice-forecasts are provided by a range of public and commercial organisations. A key player  Weathernews, the world's largest private weather service company headquartered in Japan, which provide a ‘polar routing service’ for vessels making voyage in the Arctic (see https://global.weathernews.com/news/9027/. Another company is state-owned Russian Arctic and Antarctic Institute (AARI) founded in 1920, with a network of ground stations throughout both the Arctic and Antarctica (Riffenburgh 2006: 89-90) . One interviewee described the operations of the AARI ‘as making real-time ice information easily understandable’ (interview B). The organisation provides forecasts to shippers in the form of continually updated ‘ice-maps’ which are then integrated into vessels’ navigation systems.

> They get a real map with satellite images showing how the ice is moving, showing how the ice is distributed, what are the type of ice, I mean the thickness, where the ice is moving, and provide ships with the best recommended tracks, every organisation provides a different service but the basic aim is the same; they all try to be more precise, and provide this analysis very quickly; satellite images are taken at 12 o clock, and in three hours this image should be described in detail. Experts work on this first and then provide an analysis; every six hours the maps change; you can just buy the satellite image and make your own analysis; or you can pay more and you will get a picture with analysis and recommendations [from the AARI] (interview B)

The meteorologist describes his own organisation as providing ‘tactical information’ to ships, a term which gestures to the links between meteorology and warfare (Wark 2015). The term weather ‘front’ also reflects its context of origin. Since weather affects virtually every aspect of battlefield operations, accurate weather forecasts had enormous tactical significance (Edwards 2010: 112). Meteorology developed especially during the world wars; the proliferation of aeromobile weaponry like fighter planes and long-range missiles produced a need for detailed knowledge of the upper atmosphere, and led to heavy investment in meteorological science and an increase in the density of weather observation stations around the world (Edwards 2010: 89). Detailed 'numerical weather models' were developed by the allies during WW2, and employed most dramatically on the 4th June 1944, as the allies used the cover of a successfully predicted storm to launch the Normandy invasions, in a kind of 'weaponisation' of the weather (Wark 2015: 173). 'Numerical weather prediction', writes Edwards, 'became the civilian showcase for a machine invented in wartime to support specifically military needs' (Edwards 2010: 111). Today coupled logistics and weather forecasting systems engage in a battle against the elements, where like combat, speed and timely information provision is essential to outmanoeuvring hostile elemental forces. Ice forecasting both provides information which assists in the orchestration of energy extraction and distribution, as well as provides crucial information for understanding and modelling climate change, evincing a curious paradox, where the lines between the observation and production of climate change are blurred. As Ronnskog and Palmesion argue: 'Climate-change science is both rooted in global modelling and measurement systems, and shapes the very environments it sets out to survey as it lays the foundation for an acceleration in the prospects of access to new resources' (Ronnskog, Palmesino 2014: 32). The meteorologist outlined the importance of ice-forecasts for the offshore oil and gas industry, in an extract that conjures images of military operations:

> they have very expensive equipment, time is money, they want to hire equipment, they need to plan in advance… there is increasing request [by oil and gas industry] for specific ice information. Even with a small section of drifting ice closer than such and such nautical miles, they get an alarm, and then followed up with flying helicopters, and they are on the phone to us all the time regarding the distance of the ice, and they have to have a plan for evacuating if the ice is coming [sic] close enough (interview F)

Ice-forecasting rests on innovation in 'remote sensing'. Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object, and thus in contrast to on site or in-situ observation (Jensen 2013). Remote sensing involves a seemingly paradoxical harnessing of distance in an effort to gain more fine-grained knowledge of objects or processes. Remote sensing makes it possible to collect data on dangerous or inaccessible areas. Early examples were photographs from balloons, kites, or even specially-equipped pigeons, but mostly from cameras mounted on planes (see Virilio 2009 on the 'logistics of perception' and the camera-plane coupling's transformative effects on warfare and civilian life). In the 1970s the first remote sensing satellites were launched. With satellites came the possibility of covering larger and more remote areas of the earth and get uninterrupted and very long-time series of data due to the fact that satellites can stay in orbit much longer than airplanes can fly. Satellite remote sensing detects and classifies objects and processes by means of propagated signals such as patterns of electromagnetic radiation (Chuvieco 2009: chapter three). Whilst the actual objects under observation remain invisible, objects or processes are identified by signature patterns of activity (a common analogy is determining a particular animal from its footprints). Remote sensing continues to be central to military reconnaissance, is a crucial component of the earth sciences, and is increasingly employed in urban planning, disaster management and relief, the monitoring of deforestation in hard-to-reach areas such as the Amazon Basin, and monitoring glacial features in Arctic and Antarctic regions (Chuvieco 2009: chapter one). Before satellites, knowledge of sea-ice was derived from the activities of US and Soviet military submarines, which came to acquire detailed information on sea-ice as a by-product of efforts to monitor each other's traffic submerged beneath the Arctic (Pollack 2010: 20-21).

Through satellites scientists have been able to generate vast amounts of data of the circumpolar sea-ice extent, age and thickness. Satellite data feed 'sea-ice retrieval' algorithms which once analysed provide vessels and other operations with information on sea-ice edge, type, concentration and drift. Sea-ice *thickness* however still provides a significant source of 'friction' (Day et al 2014). Being able to discern the thickness of ice is crucial to providing accurate forecasts for months in advance, i.e. where ice will melt during the summer when the shipping season commences, planning information which can aid in getting the necessary insurance coverage for journeys through the NSR. A recent paper argues that the problems posed for satellites by the thickness or the voluminous characteristics of ice, could prove a crucial obstacle to Arctic shipping routes (Day et al 2014). Remote sensing replaces what can be costly and slow in-situ data gathering processes. Yet at present 'on the ground' observations remain the most effective way of acquiring information on sea-ice thickness. Ships moving through the ice are in a better position to acquire such data than satellites, and many effectively function as 'floating scientific instruments' (Sorrenson 1996: 221; Hasty, Peters 2012: 662), collecting such data and engaging in 'applied ice-science' (Bravo, Rees, 2006: 206). Yet there is as yet no formal system in place for feeding such observations into modelling processes (interview G), demonstrating the ways in which the organisational characteristics of technoscientific networks can be as crucial as technologies in helping or hindering processes of knowledge production. Edwards calls this 'data friction' which he defines as the 'costs in time, energy, and attention needed to collect, check, store, move, receive and access data' (Edwards 2010: 84).

The discipline of meteorology has been key to the 'globalisation of science' (Edwards 2010) and to the establishment of common standards and global research networks which have reduced much data friction, through organisations like the Global Ocean

Observing System (GOOS), and the World Meteorological Association (WMO). Weather does not respect national boundaries: ‘there are no borders with weather and ice so we exceed at the borders’ (interview F). Yet even as weather forecasting networks have led to the establishment of global ties, geopolitical friction exists. The World Meteorological Organisation mandates that states have responsibility for the provision of forecast information in certain areas (figure 5.3).

> The Russians have a mandate to map the ice north of Siberia… but so far there are two obstacles; they do not have a model covering the whole area, and second even though we have an agreed international colour code standard; they put out their chart in a very different colour and Russian nomenclature, legend and everything is in Russian. This is a national thing, they want to have it in Russian, they do not want to leave the old way of doing things, so Nordic shipping firms have trouble understanding the map, so that means our ice-service had lots of interest from Norwegian shipping companies [even though the area they cover lies outside their official zone as mandated by the WMO (interview F).

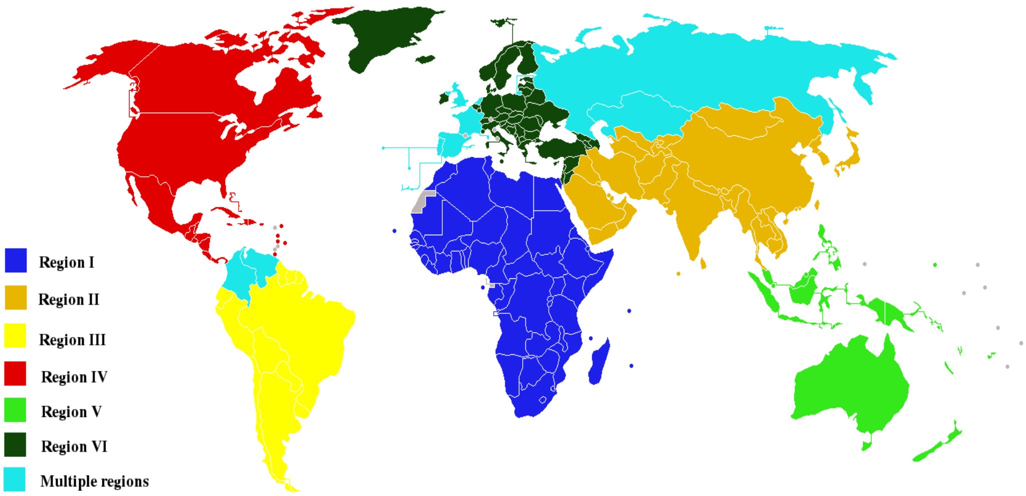

Figure 5.3. Mandated areas of the world meteorological association. Source: https://en.wikipedia.org/wiki/World_Meteorological_Organization#/media/File:WMO_Regions.PNG

There are also ways in which commercial considerations shape the provision of ice-forecasting information. Whilst 'it's not considered a bad thing to cover areas that others have a mandate to do… there is a commercial service as well, there are others out there that can compete so we cannot give it [ice-forecasts] out for free outside our mandated area' (interview F). Shipping mobilities and other maritime activities have led to the 'zoning' of ocean space as we saw in the previous chapter, but these activities are also entangled with these other forms of zoning, although these practices do not have the same geopolitical significance as the oceans.

**Communications**

Although satellites have made possible further penetration into the Arctic and increased capacities to 'know' sea-ice, the Polar Regions provide significant friction for the satellite-based systems that have come to be central to maritime communications. Ships are dependent on a range of satellite-based systems, which have a wide variety of applications, from collision avoidance, to navigation aids, to vessel tracking, and SAR. In 2000 the IMO (International Maritime Organisation) mandated that an 'Automatic Identification System' (AIS) was to be installed on all vessels with a gross tonnage of over 300, and on all passenger vessels (IMO 2000). AIS provides ships with unique identification and information such as position, course, and speed can be displayed on screens assisting vessels' officers, as well as allowing maritime authorities to track and monitor vessel movements. The AIS system relies on a patchwork of overlapping communications infrastructures, integrating a standardized, very-high frequency radio transceiver with a positioning system such as a GPS receiver integrated into on-board electronic navigation equipment (Goralski, Gold 2007). Vessel communications are increasingly routed through satellite networks. Voice and data transfer capability is required for transmission of weather forecastsand distress signals between ships and for emergency responders to coordinate operations (Farre et al 2014: 314).

Satellite coverage in the Arctic and along the NSR is highly variable, such that digital and broadband applications like the reception of modern weather and ice-forecasts, global positioning system (GPS) augmentation signals and emerging 'e-navigation' applications are not reliably available (Farre et al 2014: 314). People have been communicating at sea in the Arctic since the advent of radioat the end of the 19th century, and as we saw in the last chapter the coupling of steam-powered ice-breakers and radio communications allowed further penetration of Arctic space, making reliable cargo shipping along the NSR possible. In some ways, technological advances have made operations in the Arctic *more* difficult, as the most widely used maritime communications systems are based on geostationary (GEO) satellites that orbit the earth above the equatorial line, such as the Inmarsat and VSAT systems. GEO satellites have little or no coverage at all in the Arctic. Broadband at sea requires line of sight access to a geostationary satellite for the technologies to function effectively. geostationary satellites cannot be used above 70-75 degrees of latitude, as a result of the Earth's curvature. Current maritime digital communication systems were not designed to cover the Arctic, and maritime operators lack sufficient knowledge and information about the reliability of coverage. As of writing, the only satellite network that provides full coverage in the Arctic is a constellation known as the 'Iridium' network (Farré et al 2014: 314). However, problems with Iridium have been reported by maritime operators in Arctic areas, it occasionally shuts down and can take minutes to reconnect. The challenges with stable, high-bandwidth communications in high latitudes also cause satellites positioning systems (e.g. GPS) to have insufficient accuracy for some marine offshore operations. During loading, construction or maintenance operations, ships operate in very close proximity to facilities which require dynamic positioning with decimetre accuracy. In practical terms, what this means is that communications on board vessels transiting the Arctic are precarious, or intermittent. ‘You are on the edge of the satellite signal’, the ship’s captain informed me: ‘if you send an email you do not know if it will get there’ (Interview D). To compensate for this lack of coverage the Russian state is planning to launch a new satellite known as Arktika (interview B).

There are now thought to be some ten thousand manmade objects in outer space, not only functioning satellites, but obsolete satellites and parts, which pose risks of collision and for which there are no straight-forward means of disposal or decommissioning. This hazardous ‘space junk’ is another example of the ways modern human collectives, through infrastructures and wastes, have colonised spaces far from concentrations of people. Analogous to the crowded seas are crowded skies, with both forming part of ‘planetary urbanisation’ processes (Brenner 2014). Satellites are central to the provision not only of weather forecasting, but a range of other positioning and tracking processes, which have come to be central to sociotechnical life. Whilst satellites have been crucial in enabling societies to predict and therefore gain some control over the weather, and thus provide insulation to many human activities from the weather, they paradoxically leave societies vulnerable to ‘extreme’ weather events in outer space. So-called ‘solar superstorms’ are low-probability but high-impact events, which cause major perturbations to the solar wind, putting a number of systems at especial risk, including aviation, navigation, mobile telephony, and electricity grids, and have thus been identified as a risk to the world economy and society (Royal Academy of Engineering 2013). It is therefore crucial: ’to have continuous observations, knowing ahead of big solar outbreaks; so satellite operators can be warned and prepared to turn off equipment so it does not get damaged’ (Interview F).

So far we have examined a range of 'strategies of insulation' that aim to secure ships and cargos from turbulent surrounding ecologies, which presuppose mooring into infrastructures. We have seen how these strategies call on and presuppose globally distributed infrastructures with their own historical genealogies, most of which however are linked to warfare. We have seen how there are many gaps and discontinuities in the provision of the coverage needed – or deemed needed – to insulate ships and cargos from a particularly turbulent environment. Regulating maritime mobilities not only involves stopping the outside getting in, but also preventing unruly and hazardous materials and cargos from spilling out into surrounding ecologies, or from preventing certain materials from being carried along with cargos and then spilling into wider ecologies at points of disembarkation. Hazardous materials and 'dangerous cargos' (Mah 2015) must be channelled or contained.

**Unruly flows**

**Oil spills**

Among the ships traveling the Northern Sea Route are oil tankers carrying more than 800,000 barrels of oil. Of particular concern in the Arctic are oil spills. These spills result from drilling activity and transportation, but as Ostreng et al argue: 'shipping contributes considerably more to the overall risk of actual pollution than the oil and gas industry' (2013: 160). Spills devastate marine ecosystems, including mammals, corals, coastal wildlife, and thus have major implications for fishing, and the livelihoods and places built-around fishing. Fishing forms a major part of Arctic economies and societies, and is the main form of subsistence for many of the regions indigenous communities. Oil spills in ice are more hazardous than oil spills in open waters. The severity of a spill in the Arctic would depend on the times and conditions under which it occurred If a spill occurred at a time of high biological production the consequences would be particularly severe, and the severity of contamination would depend on the type of organisms exposed to oil, the speed of the moving oil, the type of oil, prevailing weather conditions, and the location of the spill (Ostreng et al 2013: 160).. Each spill is thus unique, and the severity of its effects dependent on the precise and contingent ways in which a range of elements combine. The slow rate of biological degradation of oil at sub-zero temperatures could mean spilled oil remains trapped in the ice for 50 years or more. Oil buried in ice retains its toxicity for decades, and can return and hit the environment again and again. The dynamics of the ice combined with the long life of oil could allow a spill to have a major effect on the albedo in the region, thus contributing further to Arctic amplification processes (Ostreng et al 2013: 159).

Effective response to oil spills requires containment, recovery and restoration. The conditions of the Arctic, and likely difficulties with accessing the site of the spill, severely constrain effective response abilities. As part of normal operations, ships produce a range of substances that must be discharged, either into the ocean or by transfer to port-based facilities (Ostreng et al 2013: 160). The IMO's MARPOL (marine pollution) convention (which came into force in 1982) stipulates the amount of oil, plastics and other debris that may be legally discharged from ships. As numerous commentators (e.g. French and Chambers 2010: 149-152) have recognised, it is thought that MARPOL regulations are routinely violated, with much illegal dumping of sludge, plastics and other detritus into the oceans. The lack of port facilities in the Arctic to receive these discharges, further incentivizes illegal dumping of wastes produced on board ships (AMSA 2007: 141). The risk of accidental release of oil and other contaminants is exacerbated by increases in shipping activity, and risks posed by spills are compounded by the lack of mitigation and response infrastructure. Currently existing oil spill response techniques in the Arctic are limited to mechanical methods, bio-remediation, in-situ burning and dispersants (AMSA

2009: 138). As demonstrated by the Gulf of Mexico disaster in 2010, dispersants can themselves cause additional problems for wildlife. The infrastructure that exists along the NSR to deal with oil spills dates back from the 1980s, and is based on the risks that existed at the time, when the volume of oil and the frequency with which it was transported were much lower (Ostreng 2013: 161). There are therefore various discharges from vessels that must firstly be prevented from leaking out, or whose mobility has to be contained when and if they occur. The business of moving oil across distances is as much concerned with preventing as facilitating its movement. Oil flows must be carefully channelled through routes. However, whilst oil spills are often (but not always) highly visible, and are very much in the public consciousness, there are other invisible or barely visible gaseous wastes produced by shipping traffic.

**Carbon seeps**

Unlike oil spills, seeps do not lead to immediate visible environmental damage but their cumulative consequences are disastrous. Exhaust fumes from vessels eject sulphur dioxide, nitrogen dioxide and carbon dioxide into the Arctic environment. Shipping contributes significantly to global climate change through emissions of carbon dioxide ($C0_2$), methane ($CH_4$), CFCs, aerosols, nitrogen oxide (N0x), sulphur oxides (S0x), carbon monoxide (C0), and particulate matter and black carbon (BC). Black carbon, which results from the incomplete metabolism of diesel fuel is now recognised as second only $C0_2$ as climate 'forcing agent' (Bond et al 2013). International shipping emits between 71, 000 and 160, 000 metric tonnes of black carbon annually (IPCC: 2007). According to the IPCC, the presence of black carbon over highly reflective surfaces, such as snow and ice, or clouds, may cause a significant positive radiative forcing' (IPCC: 2007: no page). Whilst the amount of BC produced by Arctic shipping traffic is relatively low, the region-specific consequences are disproportionate, black carbon emissions in high latitudes have a far higher per particle impact on Arctic warming than emissions originating elsewhere.

As a result of this feedback process, BC on snow warms the planet about three times more than an equal forcing of $CO_2$ (Bond et al 2013). When black carbon concentrations in the Arctic increase during the winter and spring due to Arctic Haze (discussed in chapter three), surface temperatures increase by 0.5 °C (Quinn et al 2008).

The uncertain mobilities and cascading consequences of carbon materials in an especially fragile environment are central to debates regarding the regulation of Arctic shipping. The difficult-to-predict hazards and risks engendered by the combination of ships, ice, oil, emissions and marine life, leads to calls for governance structures, or regulation. Such regulation lags behind practices. Regulation entails the production of standards to govern Arctic shipping. As of writing, a 'Polar Code' is in development by the IMO, and a draft of which has been produced, but is still not legally binding. Other than the regulations imposed by coastal states, there are no legal requirements for vessels operating in Arctic or Antarctic waters. Environmental groups have complained that the draft Polar Code is not stringent enough, particularly as the use of BC producing bunker fuels has not been banned (Yanchudis 2016). An interviewee from the Tschudi group commented on how: 'two thirds of [the Russian] fleet cannot run on light fuel… you can't just rebuild the whole Russian fleet; a eventually I think it [bunker fuel] will be prohibited but not in the foreseeable future' (interview C). Another reason for severe criticism from environmentalists concerns the lack of measures to deal with 'invasive species'.

**Invasive species**

According to marine biologists Miller and Ruiz, a 'major shift in trade-routes will alter the current landscape of marine invasion dynamics, affecting the transfer, establishment and potential consequences of invasions' (2014: 413). Commercial ships are a key pathway through which non-native marine species, including fish, crabs, microbial life as well as marine fauna and flora, are introduced into other ecosystems, contributing to 69% of species introductions to marine areas. Invasive species demonstrate the coupling of social and ecological life, threatening to disrupt ecological systems that have evolved and adapted together over millions of years, and disrupting infrastructure like port, pipes and boats, leading to significant financial losses. Ships are weighted by ballast tanks, compartments that hold water, in order to weigh a ship down and lower its centre of gravity, providing stability. These tanks take-in water from one location and discharge it at another. The opening of the Suez and Panama canals were associated with major increases in the transfer of non-native marine species. Increased shipping traffic along the NSR and NWP will connect '…world ports and their biota in unprecedented ways' (Miller, Ruiz 2014: 413).

Arctic shipping routes are significant in several respects. Firstly, Arctic shipping corridors will greatly increase the diversity and abundance of non-native organisms delivered to high-latitude regions that historically have remained isolated. Secondly, the environmental conditions and transit times are much more favourable than current trans-oceanic shipping routes. By going through Panama or Suez, ships from higher latitudes have to divert south into tropical and subtropical waters, with cold water species less likely to survive these warm waters. Moreover, the Panama Canal is a freshwater canal, so organisms clinging to the hulls of ships often undergo osmotic shock as saltwater becomes freshwater. A lot of organisms are unable to survive these conditions. Current shipping corridors therefore effectively act as 'filters' according to Miller and Ruiz (2014: 414), insulating regions from invasions and minimizing the interoceanic mobility of high latitude species. These temperature and salinity 'filters' are absent in Arctic routes, and because routes are shorter, organisms like crabs, barnacles and mussels are more likely to survive riding along inside the ballast tanks and clinging to the hulls of cargo ships (Miller, Ruiz 2014: 413). An increase in shipping to, from and via the Arctic is therefore likely to produce new 'opportunities' for interoceanic translocations of species, and substantial increases in invasions for the Arctic, which has historically 'received little exposure to such human-mediated transfers' (Miller, Ruiz 2014: 415).

Regions that have been largely isolated from shipping relative to the rest of the globe throughout the Holocene are set to become increasingly integrated, mixing marine biota in a way that's never occurred before. Invasive species could threaten the Arctic's emerging infrastructures, damaging equipment devised to look for natural gas and other natural resources. Invasive species have been described as a 'Pandora's Box', because no one really knows how they'll impact a particular ecosystem until it's too late. In an interview with Scientific American, climate scientist Jessica Hellmann stated: "Invasive species are one of those things that once the genie is out of the bottle, it's hard to put her back in" (Hellmann, cited Palmer 2013: no page).

I have identified a number of risks posed both *to* ships and cargos, and *by* ships and cargos to the Arctic. We have seen the ways in which the same pathways 'opened up, promoted, sustained, invested in for the facilitation of 'good' circulations provide opportunities for 'bad' circulations, to which they are tightly coupled' (Barker 2014: 358). This might be described as the 'dark side' of globalisation, 'a direct result of the active incitement of circulations' (Barker 2014: 358). Oil spills, invasive species and carbon emissions escape confinement within manageable limits, 'thereby threatening to drastically reduce or threaten other circulatory flows…' (Barker 2015: 2). The risks inherent in shipping through Arctic waters make *insurance* practices particularly significant.

**Insurance**

Insurance is another form of insulation. Due to the hostile conditions insurance premiums in the Arctic are higher than usual, and many underwriters are reluctant to insure at all. Underwriters traditionally rely on historical data when assessing the risks, and thus the premiums required for certain journeys, but such historical data is almost non-existent for Arctic routes. The statistics that insurance companies use to make risk assessments are simply not available, there no past trends from which to make future projections and inferences. According to Marcus Baker, Chairman of insurers Marsh's Global Marine Practice: "The number of commercial ships going through the northern sea (route) is not giving enough data to satisfy underwriters at the moment", and while: "marine insurers are largely supportive of the development of Arctic shipping routes, they are extremely wary about incurring large, high profile losses while the market is still in its infancy' (Baker, cited Lloyds 2014: no page). The lack of experienced crews and support facilities currently in place make it: "extremely difficult for marine insurers to price an insurable risk, or even agree to cover a voyage in the first place" (Baker, cited Lloyds 2014: no page). 'In cases where there are no past records', Adam and Groves argue, 'no relevant casual chains or no data, the future cannot be calculated (2007: 27).

Indeed, accessing the 'sea of data' that is such a vital part of the modern shipping system is one of the key challenges for those trying to promote the NSR, such as the Centre for High North Logistics (CHNL), partly funded by the Tschudi Group. CHNL are engaged in efforts to decrease what Edwards (2010) calls 'data friction' and improve access to information and various metrics and statistics which might otherwise remain opaque, in order to facilitate planning and insurance activities. For instance, whilst AIS data is freely available for most regions of the world, this is not so for the Arctic. Only one specialist Canadian-owned satellite is capable of identifying ship's AIS signals in the Arctic. The company which owns the satellite do not make this information freely and openly available, and so data must be purchased from the Canadian company who own the satellite (Interview B). Whilst the NSR is highly visible in certain regards, detailed historical operational information such as transit statistics, accident and damage reports, the capacities and locations of ports, and information on bureaucratic procedures, are not as readily available as they are for other parts of the world, meaning that shippers, cargo owners and insurers find it more difficult to access the information resources which increasingly underpin their activities, which in turn it is thought, discourages use of the NSR.

Whilst the insurance industry views the Arctic as a potential market, insurers':

> … main concern with the Northern Sea Route are the distances. In case something goes wrong with the ship's engine or any equipment, they would need to deliver spare parts, quite quickly. This is a problem because there is no logistic chain in the Arctic, and it may take quite a lot of time to deliver, and it's the same for urgent medical evacuation, because of the very low infrastructure in remote areas (Interview B).

**Conclusion**

Thus, a key obstacle is remoteness. Yet remoteness brings both benefits and hazards. The Arctic's remoteness tends to be figured as a problem, i.e. the distances from sources of repair and maintenance are routinely invoked as obstacles preventing the growth of the route, yet it is precisely this distance from people, from geopolitical 'hotspots' and pirates, that along with the shorter distances, is a major attraction of the Arctic for shipping in the first place. Indeed, the congestion that impedes traffic along the southern sea routes can too be seen as a problem of an excess of proximity, as vessels impede each other's passage and the risk of accidents are increased. As the captain told me regarding his journey through the NSR: 'The good thing is you do not expect any traffic; nobody is there. However, this gives you insecurity as well' (Iinterview D).

What we might call the insulating qualities of remoteness are highlighted in a report by the United Nations Environment Programme: '… the Arctic has not remained intact this long due to strong regulation and good spatial planning practices, but rather because of the remoteness from industrial centres, inaccessibility and harsh climatic conditions of this region, protected vastly by the pack ice during winter. These conditions are now changing' (Ahlenius et al, cited Jonson 2010: 831). In other words all those elements that thwart shipping, act as barriers insulating a fragile environment from industrial activities and their waste by-products.

I first examined the strategies devised to insulate ships and cargos from ice and turbulent weather conditions, and then the strategies for protecting the environment from various spills and seeps. I examined both actual and potential leaks and seeps associated with the transport and combustion of oil across Arctic waters, and documented the possible consequences of these unruly mobilities. I documented the ways in which remoteness both insulates and exposes. The next chapter examines the ways in which the Arctic's material specificities condition processes of geopolitical contestation that surround the NSR.

## Chapter six: Contesting the NSR

### Introduction

As historian of Siberia Benson Bobrick details, the 17th century saw the establishment of a functioning 'precursor' to the Northern Sea Route, known as the 'Mangazeya seaway'. The Russian White Sea settlers known as the Pomors braved the frozen waters of the Kara Sea, carving out a route running from Archangelsk to the city of Mangazeya in Northwestern Siberia (2014: 55-57). Mangazeya was initially established as an entrepot or trading colony, where the Pomors traded furs, Walrus' tusks and other goods with indigenous traders, and later with European merchants. Due to the ways in which it linked far-off spaces and places, Mangazeya soon developed into a major hub or 'gateway' through which passed both sanctioned and illicit flows of goods, people – and with them culture – between what had been relatively isolated regions. Mangazeya became 'a virtual Baghdad of Siberia, a city-state, all but independent of the Russian Empire in its wealth and utter isolation' (St George 1969: 263). The city's distance from Russian imperial centres, and its topological proximity via the Mangazeya seaway to Northern Europe, made it a threat to Tsarist Russia. The state was unable to collect taxes, and there was a fear of English trading and hence also cultural penetration into Siberia. Russia responded to this threat with draconian measures, closing the seaway to Mangazeya in 1619 on penalty of death. As well as a blockade, Russia's rulers attempted to erase all traces of the route. Navigational markings were torn up, surveillance posts established along the coast to interdict traffic, and maps altered to depict the Siberian Island of Novaya Zemlya as a peninsula, thus foreclosing the possibility of maritime access to Mangazeya (Bobrick 2014: 56-57). From imperial Russia's point of view, the Mangazeya seaway made possible a dangerous mingling of people, materials, and cultures. The city and the seaway became liminal spaces which threatened the integrity of the Russian Empire, even as they extended its reach into new territories.

The city was eventually destroyed in a fire in 1678. The city and the Pomors' early 'Northern Sea Route' were forgotten until the 20th century, when archaeologists discovered remains, preserved by the icy conditions, of a wooden Kremlin and Gostiny Dvor (indoor market) on the site of Mangazeya (St George 1969: 263-264).

Like the 'holes' in Tsarist imperial control produced by the Mangazeya seaway, tension exists between state sovereignty over, and transnational access to, the contemporary NSR. Complex and often contradictory processes of competition and cooperation between states characterise the geopolitics of the NSR, in ways that mirror the contradictions of globalisation writ large, where the imperatives of sovereignty and mobility so often come into conflict (Cowen and Smith 2009). Such dynamics are conditioned by the specificities of Arctic space, by the region's 'indeterminate and unstable geophysical characteristics' (Gerhardt et al 2010: 993). In particular, the mobility and classificatory slipperiness of sea-ice volatilises issues surrounding sovereignty and navigation rights, and this uncertainty is likely to be further compounded by climate change processes and melting sea-ice. Russian claims to legal sovereignty over the NSR are officially challenged by a number of states, although Russia's de facto control is unlikely to be seriously contested. The establishment of new global trade routes have historically been associated with major shifts in global power balances (Bosworth 2000), hence the major interest from states, media and commercial actors regarding the opening of Arctic sea routes (Blunden 2012). Rights over access to and ownership of the NSR form part of broader efforts to 'carve-up' of the Arctic and its resources, resources thought to include as much as 25% of the world's remaining hydrocarbon deposits (US Geological Survey 2008). Whilst most resource disputes have now been settled, navigation rights according to Dodds and Nuttall, 'might well be a far more decisive issue in the future as opposed to resource rights, which grabbed the global headlines in 2007-8…' (2015: 158). Whilst early fears of a militarised 'scramble' for Arctic routes and resources now appear exaggerated, following Russian military action in Crimea and NATO sanctions imposed in 2014, the Arctic has witnessed a re-militarisation on a par with the Cold War.

At the same time, however, the Arctic's 'remoteness' and harsh operating conditions, might be seen as fostering processes of cooperation, forging links between states, military, scientific and commercial actors who are induced by conditions to pool resources and expertise (Steinberg et al 2015). The militarisation of the region may even bolster infrastructure and breathe further life into the route. Yet as well as interstate rivalry, contemporary processes of contestation over the Arctic also involve 'asymmetric' conflict between environmental activists and state/carbon-capitalist interests, which may prove more significant than traditional geopolitical rivalry in the social contestation of Arctic futures. Such conflict forms part of broader global tactical struggles between activists and energy interests (Klein 2014: chapter 9). The Arctic is especially emblematic in this global struggle. The variegated processes of contestation examined in what follows involve logistics and 'counter-logistics', movement and blocked movement, in addition to 'contestation' as traditionally figured in social theory, as contest over definitions and representations. Nevertheless, defining and mapping, representation and symbolism, play a major role in Arctic geopolitics.

**Defining the NSR**

There are many 'northern sea routes'. Like definitions of the Arctic (see chapter four), the precise delineations of the route shift depending on the purposes at hand. The contours of an invisible and 'immaterial' sea route can be imagined, drawn and redrawn more flexibly than say a road, dirt track or pipeline. Start and finish points can be redefined depending on the purposes at hand. This definitional plasticity expands the range of stakeholders or actors that might be said to have 'interests' in the route, and thus who may seek to influence its development or assert some form of control over it. The characteristics of sea-ice further contribute to the legal and discursive ‘slipperiness’ of northern sea routes. Sea-ice’s propensity to shift between a solid and a liquid from, mean that not only are there varying interpretations regarding the route’s boundaries, but also varying interpretations as to whether the spaces in question can properly be considered ‘sea’ at all.

The term ‘Northern Sea Route’ is often used interchangeably with the term ‘Northeast Passage’, as European explorers had named this particular northern sea route. Russian legislation however defines the ‘NSR’ as stretching from Novaya Zemlya in the west to the Bering Strait in the East (see figure 4.2), unlike the more expansive concept of the NEP, which is customarily held as stretching all the way from the Atlantic to the Pacific via the top of the Eurasian land-mass. The establishment of the ‘Northern Sea Route’ as distinct from the ‘Northeast Passage’ was decided by the Council of People’s Commissars of the USSR in 1932 (Ostreng et al 2013: 13). The act of legally and officially defining the NSR simultaneously defined the NEP, which had never been formally delimited until the creation of the NSR. Yet in contrast to narrow legal or jurisdictional definitions, there are more ‘functional’ conceptualisations of the NSR, which whilst they have no formal legal bearing nevertheless play significant roles in the politics of the passage. Murmansk is considered the functional westerly terminus of the NSR, with Vladivostok its eastern terminus. However, once ‘functional’ criteria are invoked, the NSR could be extended to encompass the top of Norway in the west, and Japan, Korea and northern China in the east, giving these states interests in the development of the passage. Furthermore, shipping provides ‘a kind of ‘hole’ in the sovereign governance of Arctic activities, providing an important means for non-Arctic nations to claim a stake in the Arctic’s future’ (Steinberg et al 2015: 101). Thus, whilst Russia’s de facto control over the NSR is unlikely to be challenged, non-Arctic states could use the presence of ‘their’ ships in the region as grounds through which to seek further involvement in Arctic governance processes. Expertise in shipbuilding - rather than the presence of ships (which as we saw in chapter three are increasingly difficult to pin to any nation state) – may be more solid ground on which 'non-Arctic' states can plant stakes in the Arctic's future (Steinberg et al 2015).

**Controlling routes**

Attempts to control routes can take many forms, from acts of naming and defining, to efforts at monopolisation through military or legal means, to blockades, to regulating or sabotaging the flows of particular materials. The very designation of a space as a 'route' is already an invisible act of control, an attempt to increase the space's governability whilst also rendering it a 'non-space' of primary importance for the ways in which it connects other places (Gerhardt et al 2010: 995). Through the designation of a Northeast or Northwest Passage, vast swathes of territory are turned into transitional spaces of primary importance for the ways in which they connect the mega-cities of Europe and Asia. Anthropologists have documented the ways in which the notion of a 'Northwest Passage' is thoroughly alien to Inuit, for whom the same areas of sea-ice covered – or cut-through – by the NWP are places in their own right (Aporta 2011). Indeed, using GPS technology, this same network of anthropologists recently mapped the ancient, dense, but previously invisible patchwork of trails which connect Inuit communities *within* the areas Europeans have long conceived as the Northwest Passage (See http://paninuittrails.org/index.html). The contemporary imagining of the NSR as a 'short-cut' through which to accelerate the flow of cargo between centres of manufacturing in Asia and markets in Europe and Asia, follows a trajectory of figuring the Arctic as a barren but strategically vital access point, whether a shorter route for European merchants to the 'riches of the East', a waterway connecting Soviet Russia to northern and Far Eastern hinterlands (and the resources contained therein), or as the US and Soviet Union conceived the subsea and aerial Arctic during the Cold War, a shortcut for the delivery of a nuclear missile attack.

The NSR is a product of the European search for sea routes that characterised the 'Age of Discovery' (early 15th to l7th century). It must be seen within the context of European empires' battle for control over and access to routes between Europe to Asia (Steinberg 2001: 79-90). The fall of Constantinople in 1453 severed the famous overland European trade routes of the 'Silk Road' and spice routes, leading European nations to begin seeking routes east by sea. The fall of Constantinople was thus a tipping point which set modern-day globalisation in motion (Denemark et al 2000; Wallerstein 2011; Lemert 2015; Lewis, Maslin 2015). Bosworth (2000: 273-285) argues that 'blockage-circumvention-sequences' lie at the heart of geopolitical change, hence the apprehension regarding blockages to current Europe-Asia passages such as the Suez Canal, and the 'opening' of new Arctic sea routes. Changes in global trade routes have usually been associated with major shifts in global power balances (Bosworth 2000; Blunden 2012). The Portuguese and Spanish pioneered long-distance maritime travels in search of alternative trade routes to the 'Indies', moved by the trade of gold, silver and spices. As Steinberg (2009) argues, global trade mobilities coincided with the emergence of modern states, the 'inside' of the European state coming into being with the 'discovery' of an 'outside' which served as a site of colonial plunder. This point is important as it shows the ways in which sovereignty and mobility are both linked, and the ways in which states are constituted by the very flows which violate their integrity and reveal their contingency. These knots of sovereignty and mobility are nowhere more evident than in the politics of the 21st century NSR.

In 1543 Portuguese traders accidently became the first Westerners to reach and trade with Japan. Through controlling chokepoints, Portugal monopolised sea routes to

Asia, with Portugal seizing control of the Strait of Hormuz initially in 1507 and then again in 1515 (Parker 2012; chapter three)France, the Netherlands and England were left without a route to Asia, either via Africa or South America. When it became apparent that there was no route through the heart of the American continent, attention turned to the possibility of a passage through the Arctic or 'northern waters' as they were known. The western parts of what in Europe was referred to as the 'Northeast Passage' were explored by the English, Dutch, Danish, and Norwegians, looking for an alternative seaway to China and India. However Portuguese attempts to monopolise oceanic trade routes were consistently frustrated, and later a 'free seas' ideology would eventually come to govern the oceans (see chapter three). The motivation to find an Arctic passage to Asia waned therefore, even if it continued to intrigue European rulers, scientists and publics (d'Azure 1984).

The initial impetus behind the search for Arctic sea routes emerged then from blockages occurring elsewhere, not dissimilar to the blockage-circumvention processes occurring today. The impetus behind their initial 'carving out', as concepts if not as realities, was military and profit-driven before being scientific or exploratory. Yet exploration, imperialism and commerce were inextricably linked. Travelling ships were simultaneously scientific instruments engaged in mapping and exploring what were for Europeans new territories, weapons of military aggression, and 'vessels' of commerce. The practical and material links between science, commerce and exploration are arguably as close today as they were during the 1600s, even if in the 21$^{st}$ century formal distinctions between military, scientific, state and commercial activities have sharpened.

I have documented the ways in which 'northern sea routes' emerged from imperial rivalries. These routes were more fantasies than realities however, and it was not until the 20$^{th}$ century, and the emergence of the 'Soviet Union', a novel centrally-planned

‘Socialist’ state able to mobilise and exploit resources on an astonishing scale, that an actual route enabling regular and reliable passage was ‘operationalised’ or enacted (Armstrong 2011 [1952]).

**The Soviet NSR**

Immediately following the 1917 October revolution, the Soviet authorities authorized hydrographical surveys, primarily in the Kara Sea, for the purpose of improving navigation in the areas. Geographical observatories were constructed on Novaya Zemlya, Franz Josef Land and the New Siberian islands, observatories which provided the infrastructural foundation for the emergence of the RAAI discussed in chapter five. In the 1930s, plans for developing navigation possibilities for the Kara Sea were expanded dramatically, and research efforts intensified. By 1937, Glavsevmorput – the Directorate of the Northern Sea Route, formally established in 1932 – had spent the equivalent of 1 billion US dollars on activities north of 60 degrees N latitude and had some 40, 000 people on its pay role. From 1937 to 1956, the Soviet Union equipped scientific expeditions to a total of 524 different destinations in the Arctic (Ostreng et al 2013: 18-19). During the 60s and 70s it was conventional wisdom in western research circles that Soviet ‘knowledge of the region was much more extensive than that of the sum of the other nations bordering the basin’ (Sater 1969: 120-130). After WW2, Soviet research efforts were followed up by an ambitious programme for constructing a large fleet of powerful ice-breakers (Ostreng et al 2013: 19).

The creation of the NSR made possible the industrial-scale exploitation of the USSR’s Northern and Far Eastern territories, enabling the harnessing of the plentiful resources of Siberia including nickel, cobalt, coal and then oil and gas in the latter half of the 20$^{th}$ century. These resources fuelled the spectacular growth of the Soviet Union throughout the 20$^{th}$ century, and its emergence as a major geopolitical actor. The

Soviet Union could not have become a 'world power' without this massive input of resources and raw materials from its Arctic and sub-arctic hinterlands (Wood 2012). It was not only cargo but 'Soviet' forms of life and political institutions which travelled along its path. Siberia and the Russian Arctic were far from the empty barren wasteland or wilderness often portrayed in official Soviet and Western depictions. Whilst without major concentrations of people, the northern parts of Russia were and still are home to a multitude of indigenous peoples. There are 26 minority groups living in areas along the NSR, although these groups are mostly located inland and do not traverse the sea-ice in the ways that Inuit have traditionally used the areas covered by the NWP (Aporta 2011).

The largest minority group are the Nenets, who live primarily in the autonomous districts (known as 'Okrug') of Nenets and Yamal Nenets, and the Chukchi, living in the district of Chukchi. Nenets reindeer herdsmen were made to adopt official Soviet forms of organisation and underwent forced integration into Soviet society. Traditional reindeer herding activities were reorganised into state-owned collective systems identified by numbers, transforming traditional indigenous communities, which consequently suffered a major decline in traditional economic activities (Thomassen et al 1999: chapter five). The NSR was therefore a key technology of Russian colonialism, helping in both the deliberate disciplining and assimilation of indigenous populations through the imposition of new forms of governance and organisation, and through the unintended disruptions to traditional forms of life wrought by the industrialisation of the North, which the establishment of the NSR made possible (Ostreng et al 2013: chapter 6).

As well as integrating distant people and territories, the establishment of the NSR also enabled the Soviet Union to remain isolated from the rest of the world. The USSR's political 'isolationism' had an infrastructural underpinning.  Without it the Soviet

Union would have had to use sea routes that passed through or close to the territorial waters of NATO states. Besides being the shortest seaway between the western and Far Eastern USSR, it was the only section of sea that did not overlap with the waters of neighbouring hostile states. By drawing together the previously dispersed, the NSR was implicated in the production of Soviet territorial coherence.

**WW2 and Cold War Arctic**

The NSR also played a minor role in WW2. In the summer of 1940, the Soviets allowed a German auxiliary cruiser known as *Komet* to use the route and thus evade the British Royal Navy and break out into the Pacific Ocean. Komet was escorted by Soviet icebreakers during her journey. After the start of the Soviet-German War, the USSR transferred several destroyers from the Pacific Fleet to the Northern Fleet via the Arctic. The Soviet Union also used the NSR to transfer materials from the Soviet Far East to European Russia, and the Germans launched Operation Wunderland to interdict this traffic (Armstrong 2011: 10). The allies also used an Arctic route to deliver materiel to the Soviet Union, known as the Arctic Convoys of WW2, which involved some of the deadliest battles of the conflict (Walling 2012).

But it was, fittingly enough, during the 'Cold War' that the Arctic really emerged as a 'theatre' of military operations (Farish 2006). Militaries were perhaps amongst the first nonindigenous actors to apprehend the world through a circumpolar optic. As early as 1935, US General Billy Mitchell maintained in a speech to congress: 'Alaska is the most central place in the world… He who holds Alaska holds the world' (Mitchell 1935, cited Ostreng et al 2013: 48). Mitchell reasoned that aircraft and the aeromobilisation of military conflict granted Alaska this new strategic centrality. Developments in military mobilities during WW2, combined with the geostrategic location of the Arctic Ocean between the world's two 'superpowers', made the Arctic a suitable area for the deployment of high-tech weapons systems. Due to its location, the Arctic became an integral part of conflicts originating in southern latitudes. The Arctic became a central theatre of operations in this ‘bi-polar’ world made-up of two warring supper blocs, even if the Arctic’s military significance remained little appreciated by the general public. In the 1950s and 60s, Arctic airspace was conceived by military strategists as an attack route for bombers, and as the shortest route through which nuclear warheads could travel between the US and the USSR. In the 1970s, new generations of intercontinental ballistic missiles further entrenched this deployment pattern, with not only Arctic airspace but also its subsea portions conceived as possible attack routes (Ostreng 2013: 49). The swift transformation of the region into a military arena points to the link between geography, technology and military and political might (Mahan: 2014 [1890]; Mackinder 2015: [1905]). Yet the same geographical features – and technological infrastructures - can serve both ‘economic’ and ‘military’ purposes. For instance, the military shipyard where the Soviet Union’s nuclear submarines were built, Severodvinsk outside the city of Arkhangelsk (figure 6.0), has now become a key node in the construction of ice-capable oil and gas drilling platforms (6.1), demonstrating the ‘mooring’ of contemporary economic activities in Cold War military infrastructure. Indeed, much of the scientific knowledge produced about the Arctic, particularly its subsea areas, was generated by militaries during the Cold War, as a by-product of hunting each other’s submerged traffic (Pollack 2010 20-21: Dodds, Nuttall 2015: 64-72).


Figure 6.0. US military satellite images showing a Soviet submarine docked at the Severodvinsk shipyard in 1969. Source: Wikimedia Commonshttps://commons.wikimedia.org/wiki/File:Satelite_image_of_a_Typhoon_Class_Submarine_Severodvinsk.jpg

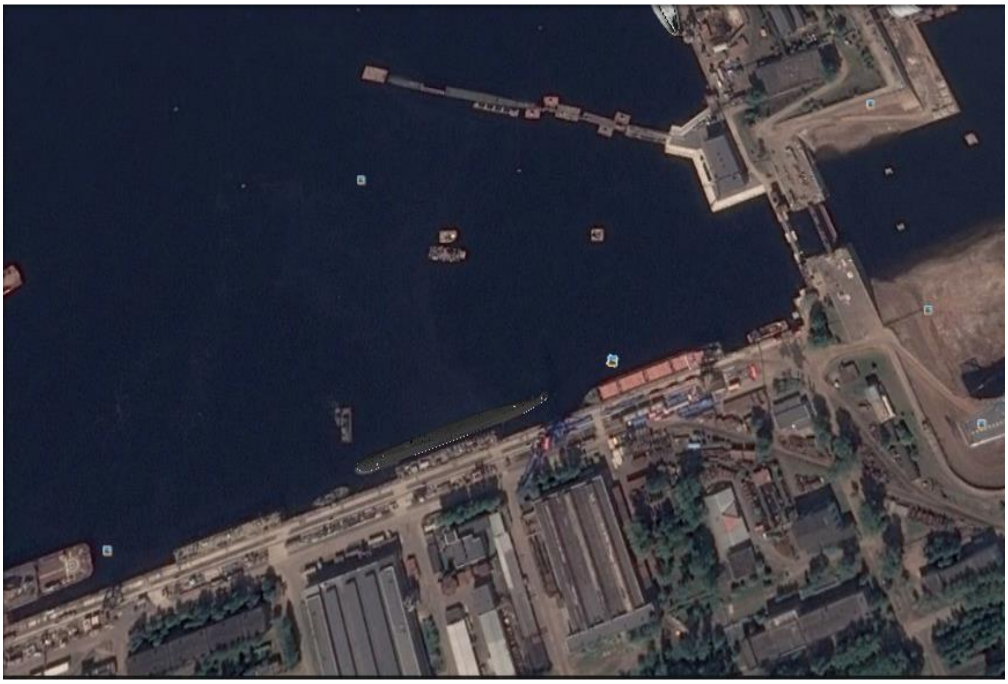

Figure 6.1. Severodvinsk shipyard 2015. Source Google Earth.

**Carving up the Arctic**

The Cold War ended with the almost overnight collapse of the Soviet Union in 1991, an event that turned out to be a tipping point for global politics and economy (Gaddis 2007). From then on the 'Russian' Arctic moved increasingly away from the closed and heavily militarised bastion that it had been in the 20th century, to an area more open to transnational penetration and international cooperation. Yet Cold War legacies and rivalries continue to haunt the Arctic, and in the last year a remilitarisation of the area has taken place. In the 21st century, climate change processes are driving efforts to 'carve-up' the Arctic and its resources, a carving-up which involves both cooperation and competition between states. In 2007 an expedition journeyed to the North Pole, planting a Russian flag at the bottom of the Arctic Ocean, an event which was accompanied by Russian President Putin's assertion that 'the Arctic has always been Russian'. Unlike Antarctica which is basically a continent surrounded by sea and governed by an international treaty, the Arctic is a sea covered by ice and surrounded by land, occupied (if often intermittently) by people falling under the sovereign jurisdiction of a state. All land and territorial waters in the Arctic belong to one of the five countries with Arctic coasts, Canada, Norway, Russia, Denmark (via Greenland), and the United States (via Alaska). Whilst most of the region's state boundaries are not disputed, the specific geography of the Arctic, in particular its exceptionally complex underwater topography and the mobile characteristics of sea-ice, at times complicate boundary drawing practices.

The central area of dispute is the Arctic Ocean, governed by UNCLOS (the international legal framework for ocean-space governance, see chapter three). Under international maritime law, waters including the North Pole and the region surrounding Arctic Ocean are not owned by any country. The five surrounding Arctic countries are limited to an exclusive economic zone (EEZ) of 200 nautical miles adjacent to their coasts. The waters beyond the territorial waters of the coastal states are considered the ‘high seas’ (i.e. international waters). The sea bottom is considered to be the ‘heritage of all mankind’ and administered by the UN International Seabed Authority. The two main ways in which coastal states may extend their sovereign rights are the Exclusive Economic Zone (EEZ) and the Continental Shelf (CS). The CS concerns exploitation of natural resources under the seabed. Geologically, the continental shelf is the extension of the landmass into the sea, and in legal terms this continuation of the land constitutes an extension of sovereign rights into the sea. The desire to expand sovereign rights to the seabed makes sense only in relation to technological developments that made it possible to exploit the seabed and its resources. Seismic vessels made possible new forms of underwater prospecting and offshore oil extraction technologies have advanced considerably since the 1960s (Vidas, Schei 2012: 65-99).

The most visible controversy remains the allocation of sovereign rights over the boundaries of the underwater ‘continental shelves’ of coastal states. An area of the Arctic including the North Pole currently lies beyond every nation’s 200 nautical-mile limit. Arctic states are making claims to extend their sovereign rights, a process involving the frenetic criss-crossing of the ocean floors by submarines engaged in mapping the seabed through sonar technologies (Ronnskog, Palmesino 2014: no page). The Arctic’s underwater topography make this a particularly protracted and convoluted process, involving years of scientific research and data gathering, submissions and re-submissions to UN agency the Commission on the Limits of the Continental Shelf (CLCS), which assesses whether a series of bathymetric and geological criteria are met which would permit the respective coastal states to claim exclusive rights to the non-living resources of the seabed (Steinberg 2015: no page).

The Russian Federation asserts that an unusual underwater feature, a ridge of continental crust named the *Lomonosov Ridge* first discovered by Soviet high-latitude expeditions in the 1940s, is an extension of the Siberian continental shelf. The Russian Federation is claiming rights over an area stretching all the way to the North Pole, based on the existence of this ridge. However Greenland, an autonomous country within the Kingdom of Denmark, has the nearest coastline to the North Pole, and Denmark argues that the Lomonosov Ridge is in fact an extension of Greenland. International lawyers have stated that it is very difficult to prove that the two ridges are part of any continental shelf (Dodds 2008; 2010). Canada and Denmark consider basing a territorial claim on the Lomonosov Ridge as well. Denmark is the latest state attempting to lay claim to the North Pole. Whilst the North Pole is unlikely to contain any resources, it is of enormous symbolic significance. Instead, the Danish move, it is speculated is part of efforts to shore up its popularity in independence-seeking Greenland, where the claim enjoys support (Barkham 2014).

The hidden, subsea areas of overlap between states can help us conceive of the ways in which distinctions between states and displays of sovereignty are, especially in the Arctic, underpinned by hidden transnational connections. For all their surficial nationalism, expeditions and displays of sovereign exclusivity are made possible by transnational links and cooperation; the 2007 expedition which planted a Russian flag at the bottom of the Arctic Ocean was organised by an Australian-American group of deep-sea exploration enthusiasts and funded by a Swedish pharmaceuticals magnate (Steinberg et al 2015: 21).

**Contesting the NSR**

Dodds and Nuttall argue that: ‘Whilst much attention has been given to subterranean mapping of the seabed and a potential extension of sovereign rights over the outer continental shelf, navigation rights might prove more decisive’ (2015: 158). The exercise of national jurisdiction by Arctic states Canada and Russia could be a source of tension as national regulatory structures and practices coexist 'uneasily with the mobilities of extra-territorial parties' (Dodds, Nuttall 2015: 155). On the one hand Canada and Russia seek to territorialise the NWP and NSR respectively. On the other hand, extraterritorial parties such as China, the US, South Korea and Japan 'conceive of an ice-free Arctic as essentially offering opportunities to treat the Arctic as distinctly unexceptional, where mobility is not impeded by overzealous coastal states' (Dodds, Nuttall 2015: 156). At the same time however, the transnational mobilities of extra-territorial parties are being enrolled in performances of Russian sovereignty over the NSR.

Yet the (im)mobilities of ice are also of central importance to these dynamics. Sea-ice shifts between solid and liquid states, and occupies an uncertain or liminal position between land and sea, posing problems for attributions of sovereign rights over both the NSR and NWP. An implicit, 'common-sense' materiality holds land and sea to be 'the Earth's two essential surface features' (Gerhardt et al 2010: 993). Historically 'ideals of sovereignty have assumed a basic elemental distinction between land, recognised as amenable to sedentarization and hence territorialisation, and water, designated as resistant to these assertions of control' (Gerhardt et al 2010: 993). Ice however undoes this land/sea binary thereby *scrambling* this elemental common sense. 'At its most basic level, the binary division of the earth into land and water is confounded in the Arctic by the presence of ice, a… substance that combines and confuses properties of the two' (993). Whilst UNCLOS stipulates that states have sovereignty over a 12-nautical mile radius and can claim additional jurisdiction over a 200 nautical mile area around their coasts, coastal states are duty-bound to allow the 'innocent passage' of trading vessels even within these boundaries. However, the legislation makes an exception for areas of sea where 'particularly severe climatic conditions and the presence of ice covering such areas for most of the year' (UNCLOS 1982: article 234) prevail. Only Russia and Canada have coastal waters which remain 'ice-covered for at least half the year' and this therefore affects the legal status of both – and only – the NWP and NSR. Both states are committed to monitoring and where possible administering the movement of commercial shipping (Dodds, Nuttall 2015: 45). Due to the 'the particular sensitivity of ice-covered regions' (UNCLOS 1982: article 234), littoral states are granted rights to interfere with vessel traffic, including ensuring this traffic adheres to whatever national environmental legislation coastal states have in place, including the right to charge transit fees to foreign flagged ships. Ironically, Russia uses a piece of environmental legislation (UNCLOS article 234) as the legal basis for the establishment of a potentially highly polluting shipping system (see chapter five on the disproportionate effects in high latitudes of emissions associated with shipping).

As temperatures rise and ice melts however, Russia's legal choke-hold over the NSR becomes more tenuous. Application of article 234, the UNCLOS clause which grants extended jurisdiction over ice-covered regions, becomes open to challenge, as the waters in question are unlikely to remain ice-covered for the majority of the year for much longer (Wang, Overland 2009). Russia thus find themselves in an intriguing position; as the ice melts the NSR looks set to attract more traffic. Yet at the same time the tenuous legal settlement which grants them sovereignty rights over the passage becomes increasingly open to challenge. Perhaps in anticipation of such challenges, between 2012 and 2013 the Putin government issued a series of directives which established a new legislative body to administer and handle applications for transit along the NSR, which reinforces the bureaucratic procedures necessary for foreign vessels, and redefined the contours of the route (Dodds, Nuttall 2015: 45).

These directives were a legislative reinforcement of Russian control, a sharper carving of Russian lines of sovereignty.

The ways in which the mobilities of sea-ice rearranged the mobilities of transiting ships was central to this legal thickening, stretching and redefining of the NSR in the Russian Duma in 2013. There are times when transiting vessels are forced to veer outside areas deemed to come under Russian jurisdiction. However, under new laws passed in the Duma in 2013, the areas that vessel convoys veer into can still be defined as coming under full Russian jurisdiction and control. According to Russian legal scholars Kolodkin and Kolosov: ‘The integral nature of the Northern Sea Route as a transport route is not affected by the fact that individual portions of it, at one time or another, may pass outside the aforesaid boundaries of (i.e. boundaries of internal waters, territorial waters and economic zone) whereas the USSR exercises it’s sovereign rights or sovereignty in full…’ (1990: 164). Thus, as long as part of the voyage includes waters under Russian jurisdiction, according to this reasoning, the right to define the NSR to include sea lanes running beyond its own economic zone in high latitudes, even close to the North Pole. In principle, this implies that all conceivable lanes south of the North Pole – and even across the Pole itself – might be part of Russian waters as long as voyages pass through Russian waters at some point. According to this definition, the NSR encompasses the TPR (Transpolar Route), the most direct of the three circumpolar sea route which passes straight through the North Pole. The NSR can be conceived as part of an interconnected rectangular transportation system for the Russian north. In addition to the passage itself the legs of the rectangle consist of the big Siberian rivers and the east-west running railways in the south connecting with the rivers thousands of miles from the coast. From this point of view the NSR extends northwards and southwards from the coast, servicing huge ocean and land territories, covering thousands of kilometres from the North Pole to the railways to the south. Here the NSR is not defined so that it stays within the boundaries of Russian waters, but Russian waters are extended as the NSR passes through them. This is the use of a transportation infrastructure to extend sovereign rights.

The US (not a signatory to UNCLOS it should be noted) and China already dispute Russian claims to ownership over the NSR, as well as parallel Canadian claims over the NWP. In September 2014, the remains of one the ships from the ill-fated Franklin expedition which left England in search of the Northwest Passage in 1846, was found off the coast of Nunavut (discovered accidently through oil prospecting), a lost object that has become enrolled in Canada's efforts to lay claim to the passage. China could well contest Russia's claim to sovereignty over the NSR more vociferously in the near future. The PRC's model of economic growth presupposes demand for its manufactures emanating from distant places, with a growing reliance on the outside world and the oceans, with around 46% of China's GDP shipping-dependent (Blunden 2012: 125). As a maritime economy, China effectively stretches out into and functionally encompasses the seaways and strategic choke-points through which it moves goods out, and brings resources in, rendering this economy vulnerable to disruption. The Chinese state is therefore increasingly engaging in 'out of area' operations such as against piracy off the coast of Somalia. The NSR is sometimes referred to as the 'Golden Waterway' in China, due to the ways it could offer a way out of what has been called the 'Malacca Dilemma', the way the country's dependence on imported resources – particularly oil – renders its entire economy hostage to a small stretch of sea, the Malacca Strait (French and Chambers 2010). But many within Chinese policy circles are suspicious of Russia's control over the passage, particularly the possibility that Russia could charge exorbitant transit fees. Contestation could therefore intensify, especially were the route to become significantly integrated into the Chinese economy. Huigen Yang, Director General of the Polar Research Institute of China stated in 2013 that China could transfer up to 15% of its international trade through the Arctic by 2020 (Yang, cited RT.com 2013: no page). One Chinese naval expert states: ‘whoever has control over the Arctic route will control the new passage of world economics and international strategies’ (Li Zhenfu, cited Jakobson 2012: 6).

However closer scrutiny reveals a more complex picture than the rather simplistic geopolitical narratives of states – driven by climate change – fighting for competition over routes and resources. Much as transnational interests are engaged in developing Russian Arctic resources, so too are foreign states and companies central to developing – and even to Russian performances and enactments of sovereignty over - the NSR. The Russian state is dependent on the very extra-territorial mobilities which threaten its sovereignty. Even as there are anxieties over how Russia might control the flow of foreign vessels, including possibly warships, from entering and transiting its territorial waters, given the revenues generated by ice-breaker escorts and administration fees, Russia is also keen to increase commercial traffic along the NSR. Thus, similar to the dynamics explored in the previous chapter, the problem for the Russian state is the ambivalent nature of circulation, which is both crucial to the health of the state and the economy, but which is also the main source of insecurity faced by states.

Indeed, in many ways it is only through the passage of foreign vessels that Russian sovereignty over the route is enacted. Through agreeing to Russian terms and conditions, through mobilising Russian ice-breakers and ice-pilots, and the whole bureaucratic machinery of the NSR administration, foreign-flagged vessels reinforce or help to carve-out Russian sovereignty over the route. Yet at the same time shipping produces a kind of ‘hole’ in the sovereignty of Arctic nations.  A functional – rather than a legal definition of the route could be made to encompass not only the ports of Murmansk but northern Norway and the port city of Kirkenes. As has been pointed out: ‘If Vladivostok is the functional Russian eastern end point of the NSR, then the neighbouring countries of Japan, North Korea, South Korea and China can easily become functional end points as well’ (Simonson 1996: 6). Russia’s efforts to regularize use of the Northern Sea Route by foreign nations vessels might reaffirm Russia’s claim to sovereign jurisdiction, but could also establish the presence of non-Arctic (and non-Russian) states and companies as Arctic players, which could then be used to support requests, for example, for permanent observer status on Arctic Council, the region’s main governance body (Steinberg et al 2015: 101). China is showing growing interest in the NSR and the Arctic, and in 2010 was granted observer status on the Arctic Council.

Contestation over the NSR and the Arctic in general remains largely legal and diplomatic in nature and fears of a military ‘scramble’ for the Arctic and its resources have so-far been proved wrong. Indeed the region is in practice characterised by high levels of interstate cooperation, as the difficulties posed by operation in the region seem to be forcing a kind of pooling of knowledge and resources. None of the Northeast Asian countries projects power north of the Arctic Circle in a conventional military manner. Instead argues Bennett, ‘they use their ice-breakers to conduct scientific expeditions in the region, shoring-up their soft power with the use of heavy-duty, high-tech (and for South Korea and Japan, domestically built) infrastructure (Bennett 2014: 73). A key legal agreement was the Ilulissat Declaration of 2008 in which the five Arctic states endorsed and reaffirmed UNCLOS as the fundamental legal framework under which it would continue to operate to adjudicate conflicting territorial claims, protect marine environments, and regulate shipping (Ilulissat Declaration 2008). As well as re-inscribing UNCLOS as the primary instrument of ocean-space governance in the Arctic, the declaration also re-affirmed Arctic coastal states as the key players. The agreement only involved the five coastal states, and not the Arctic Council (which also includes Iceland, Finland and Sweden, states that do not have an Arctic coast). Yet in 2011 the Arctic Council passed a Search and Rescue Agreement for shipping in Arctic waters. This was the AC's first legally binding agreement, demonstrating the ways in which Arctic governance institutions are themselves being 'carved' through the regulation and production of shipping networks (Dodds 2013).

**'Cold War 2.0'**

The Russian Arctic has gone from a closed Cold War bastion to an increasingly networked space permeated by transnational shipping, resource extraction and scientific research activity. Yet this political and economic 'opening-up' of the Russian Arctic is partial and precarious, and as recent events have demonstrated, could be knocked off course or even go into reversal. Indeed, the High North has re-emerged as a front in what some are terming 'Cold War 2.0'. Arctic geopolitics are enmeshed in broader global currents, with activities occurring far-away having repercussions for the Arctic. In March 2014, the internationally recognised sovereign territory of Crimea was annexed by the Russian Federation. Then in July 2014 a Malaysian airliner was shot down over the Russia-Ukraine border killing 298 passengers and crew, allegedly by Russian-backed Ukrainian rebels. 'Targeted' sanctions were then imposed on Russia by NATO.

Whilst efforts to bolster Russia's military presence in the Arctic date back to the directives issued by the Putin government in 2013, recent events have given these processes more intensity or momentum, and from the point of view of NATO states and their media, more sinister resonances. It appears that a series of 'scrambles' or bursts of frenetic military activity are underway (Dodds and Nuttall (2015: xiii). 2014 witnessed a surge of reported (but not always verified) Russian military incursions into the sovereign territories of NATO states, including a submarine detected off the coast of Sweden, a squadron of Russian warships purportedly in the English Channel, and a Russian fighter jet reported to have entered UK airspace. These shadowy movements and incursions were likely intended to demonstrate Russian military 'mobility' (in the military sense of the word, where it designates a force's 'reach'), and show 'this can be done' – not dissimilar to the demonstration voyages along the NSR (although rather than performances of sovereignty they are performances of the ability to violate sovereignty. See Williams 2009). Unverified reports of Russian planes and submarines mobilised domestic security services and produced a flurry of rumours and speculation in the countries whose boundaries were supposedly breached.

Securing the NSR and adjacent resources is a strategic priority for the Russian Federation, and a string of Cold War bases are being upgraded and re-occupied, with Russia set to deploy military units along its entire 4,700-kilometre Arctic coast. In 2014 a military base near the Finnish border capable of holding 3,000 soldiers was reopened, with a nearby military airport scheduled to open late 2015. Two northern bases in the Novosibirsk Islands and in the Franz Josef Land archipelago are being re-built. In July 2015, Russia tested a new-generation of rockets from a station in the Arctic, and a military drone base 420 Miles off the Alaskan Coast is planned for development (Sharkov 2015).

In December 2014 President Putin announced that Russia's 'Arctic Command' had become operational. Over a five-day period in March 2015, for the first time since the Cold War, Russia carried out extensive combat exercises in the Arctic, involving some 80,000 troops, 220 aircraft, 41 ships, and 15 submarines. There was much speculation in NATO circles regarding the aim of the exercise, which unlike the aforementioned incursions took place within areas under Russian sovereignty. The exercise could be seen as a way to 'stress test' the command and control capabilities of the new Arctic Command, and the logistical capabilities of the network of bases that have been (re)established in the region (Faith 2015).

Russia's Cold War adversary the US is also engaging in military activities in the North American Arctic, planning to install 'multi-purpose sensors' in Canada's Arctic that would be capable of detecting a wide range of potential threats, including ships, airplanes and cruise missiles fired off by a 'rogue state' such as North Korea. Admiral Greenbert of the US Navy declared that:

> In our lifetime, what was [in effect] land and prohibitive to navigate or explore, is becoming ocean, and we'd better understand it. We need to be sure that our sensors, weapons and people are proficient in this part of the world [so that we can] own the undersea domain and get anywhere there (Greenbert cited Friedman 2014: no page)

The traffic increases associated with military activity increase the risk of accidents and may be said to contribute to overall turbulence. But given the significant overlap and shared lineages between civilian and military logistics infrastructure, bolstering military presence could provide more favourable conditions for commercial shipping and resource extraction activities. The astonishing scale of the March 2015 deployment has led to speculation that the exercise was intended not only to 'stress test' the capacities of Russia's Arctic military command, but also to demonstrate the reliability of Arctic infrastructure for the extractive and shipping industries (Faith 2015: no page). Indeed, an interviewee stated that militarisation would entail: '… an improvement of infrastructure coming from the point of view of safety at sea, as more military bases, mean more people in the area and more facilities for search and rescue' (Interview B). It is not just people, however. Russian authorities recently announced that military drones will soon start monitoring parts of the NSR. 'The drones task', according to Colonel Aleksandr Gordeev, was to 'maintain impartial control of the situation in the Russian sector of the Arctic, including the ecological and ice situation in the adjoining sea areas and along the Northern Sea Route" (Gordeev, cited RT.com 2015: no page). As the ice melts, other challenges and issues of control emerge, as 'non-state' actors contesting resource extraction attempt to draw attention to, interfere with or interrupt related oil and gas and mobility activities in the Russian Arctic. The next section looks at the ways climate change activists are seeking to disrupt shipping and oil and gas activity in the Russian North.

**Arctic Blockadia**

'Whereas many news articles are focusing on the potential for a "new cold war" between Arctic states', argues Mia Bennett, 'the real struggle in the Arctic and in other parts of Russia's hinterlands may be between state and non-state actors, whether they are environmentalists or, in the eyes of Putin, terrorists' (Bennett 2014: no page). Shipping forms part of a wider 'fuel-and-energy complex' which forms the 'lifeblood of Russia's economy' in President Putin's words (Duma 2014). Oil and gas interests are pushing relentlessly into new territories, in a process sometimes referred to as 'extreme energy' (Klare, cited in Gross 2010). Klein poignantly describes the spread of extraction infrastructure as resembling an oil spill: 'Like an oil spill that spreads from open water into wetlands, beaches, riverbeds and down to the ocean floor, its toxins reverberating through the lifecycles of countless species, the sacrifice zones created by our collective fossil fuel dependence are creeping and spreading like great shadows over the earth' (Klein 2014: 315).

Energy routes are increasingly potent sites of material and symbolic struggle. There is a struggle here between oil and gas logistics and what we might call a disruptive 'counter-logistics' (Degenerate Communism 2014). Whilst more navigable waters may allow easier access to resources, it can also facilitate access to those wishing to disrupt extraction activities. The MV *Arctic Sunrise* incident which involved the storming of a Greenpeace vessel by armed Russian coast guards, and subsequently the imprisonment of 28 protestors and 2 journalists, provides a good example of this kind of asymmetrical conflict, which involve a combination of logistic and symbolic contestation. 'The rise of Blockadia', the logistical activism that has emerged in response to continued energy extraction activities, is in many ways, 'is simply the flip-side of the carbon boom' (Klein 2014: 310) 'Blockadia is not a specific location on a map but rather a roving transnational conflict zone that is cropping up with increasing frequency and intensity wherever extractive projects are attempting to dig and drill…' (Klein 2014: 295). Examples include the on-going activism along the path of TransCanada's 'Keystone XL' pipeline which involves coalitions of activists forming actual blockades rather than the usual symbolic protest of placards, petitions and 'consciousness raising'. Yet these blockades have enormous symbolic or affective resonances, especially when they manage to gain the media spotlight. 'Blockadia' goes wider than environmental activism and represents a shift in contemporary forms of protest, which have become logistical (Bryant 2012; Capps 2014; Goodyear 2014)

'In the midst of the 2010 Deep Horizon oil spill disaster in the Gulf of Mexico, we glimpsed a possible Arctic future, which was arguably more disturbing than the 1989 Exxon Valdez shipping accident because of the real-time imagery of oil seeping into the marine environment' (Dodds 2012: 5). The possible future Arctic oil spill provides a powerful symbolic resource on which environmental activists draw to galvanise opposition to carbon capitalist interests and extraction activities in the region. Transposed to a high Arctic environment, 'the oil spill accident as disaster is all the more poignant, oil trapped in and under the ice-filled waters of the Arctic Ocean threatening microscopic and large scale life' (Dodds 2012: 5). Here, rather than ice's impermanence, it is ice's archival properties that come into focus. But whilst the future possible major catastrophic spill event garners all the attention, mundane, invisible and unremarkable spills occur all the time; of particular significance are the black carbon emissions associated with ships, which the recently devised 'polar code' which seeks to regulate shipping activity in the region has not banned, despite evidence that the latter has disproportionate consequences in ice-covered regions, which absorb carbon and contribute to loss of albedo. Focus on exceptional spill events can obscure the hidden but routine spills which form part of the normal operation of the energy extraction and mobility nexus. In an interview with the author, Greenpeace's 'logistics manager' said that the organisation's monitoring of Russian oil and gas activities revealed that the amount of oil spilled on land in Siberia in the last few years was the equivalent of 'one deep water horizon per year' (interview E). Greenpeace want a moratorium on drilling in the Arctic, similar to that in place in Antarctica, where there is currently a 20 year ban on resource extraction activity. 'Energy-security' for Greenpeace is not securing supplies from ever more dangerous and distant locations but requires investment in renewables (interview E).

The Prirazlomnoye offshore oil field began producing oil in 2013. There are an estimated 71.96 million tons of recoverable oil in this field, with a target of 300,000 tons to be produced this year and six million to be produced annually after 2020. Unlike the Yamal LNG Project, a joint venture project between Russia's Novatek, France's Total, and China National Petroleum Corporation, the Prirazlomnoye oil field is a more nationally-driven endeavour. In Russia, Arctic oil production is seen as necessary to offset declining reserves in West Siberia. Still, foreign expertise was necessary in making possible the export of the first barrels of oil from north of the Arctic Circle. A ship designed by Finland's Aker Arctic Technology exported the first shipment of oil from Prirazlomnoye. Viktor Petrov, head of the Kola Center for the Defense of Wildlife, remarked in an interview with Bellona, "There is a more than likely chance of an oil spill resulting from the operation of the Prirazlomnaya platform' (Petrov, cited Digges 2014: no page).

On 28th August 2013 the *Arctic Sunrise* attempted to enter the NSR on its way to protest against the activities of the Prirazlomnoye offshore oil field. A Greenpeace press release stated: 'Greenpeace International entered three detailed applications for entry to the Northern Sea Route Administration, clearly stating its intentions to engage in peaceful and lawful protest. All applications were rejected. It was clear that the NSR administration were never interested in granting Greenpeace access. The refusal was in violation of international law including the right to freedom of navigation' (Greenpeace 2013). On 30th August 2013 Greenpeace decided to enter the NSR on their way to Prirazlomnoye in defiance of Russia's ban. On 3rd September the vessel reached the Prirazlomnoye field. The activists on board were able to get close enough to the oil rig to climb onto it. Greenpeace's 'logistics manager', who was on the vessel, describes the action which unfolded:

> We were not prepared for the violence and ferocity we encountered. Gazprom employees hurled slices of metal at us, some as large as Iphones. Some of the activists were able to enter our 'pod' [a custom-built, bullet-proof vessel described as 'survival capsule'; a 'home away from home'] and upload videos of the incident literally as the ship was being boarded (interview E).

The *Arctic Sunrise* (figure 6.5) was then boarded from a helicopter by a heavily armed Russian Coast Guard unit. The protestors were quickly arrested and their ship towed to shore, and then jailed for three months on charges of piracy, charges which were subsequently downgraded to a lesser charge of 'hooliganism'. The initial use of anti-piracy legislation demonstrates the ways in which the concept has travelled and taken on new incarnations.  Although the so-called Arctic 30 were released, Greenpeace's ship remains detained in Murmansk. The Russian government were pressured by high profile campaigns with demonstrations in 49 different countries. The incident was far from the NSR, but it gave an opportunity to demonstrate 'Russia's willingness and capability to act in the region' (OilPrice.com editorial: 2013). Whilst the capture by Russian forces of the *Arctic Sunrise* was ostensibly about protecting an offshore oil field, some speculate that the incident and the subsequent detention of Greenpeace activists was a way of demonstrating control over the NSR (OilPrice.com editorial 2013).


Figure 6.3 Wikimedia Commons

https://commons.wikimedia.org/wiki/File:Arctic_Sunrise_in_Libya_1.jpg

In 2014 the Russian Duma signed into law an act: 'on the establishment of departmental security to ensure the safety of the fuel and energy complex' (Duma 2014). The law allows corporations to establish their own private security forces to defend their infrastructure, ‘upping the stakes of oil production in the Russian Arctic while rendering protestors even more vulnerable’. The ‘possibility of paramilitary forces protecting Russia’s oil and gas infrastructure throws a whole new wrench into the Arctic energy race’ argues Bennett (2014c: no page).

The seizure of the *Arctic Sunrise* has not spelled the end to Greenpeace’s activities. On April 18 2014 Gazprom sent the first barrels of oil from Prirazlomnaya to the port of Rotterdam. The oil from the Prirazlomnaya rig is transported by ship, as the offshore field is not connected to any pipelines. ‘Shipping the oil by sea’ Bennett observes, ‘conveniently allows Russia to circumvent political hotspots like Ukraine, but it also opens it up to other potential disruptions; it can’t avoid well-equipped, well-funded environmental protestors such as Greenpeace, which owns three ships’ (2014: no page). As soon as *Mikhail Ulyanov*, a tanker chartered by Gazprom set sail from the Prirazlomnaya platform with 550,000 barrels of Arctic oil, Greenpeace protestors aboard the *Rainbow Warrior III* began tracking it down. On May 1, when the *Mikhail Ulyanov* arrived in Rotterdam, Rainbow Warrior III was there to greet it with a fleet of paragliders and inflatable rafts. Greenpeace protestors painted on the side of the Russian tanker, “NO ARCTIC OIL,” and sandwiched themselves between the tanker and the dock to try to stop it from mooring. Dutch authorities promptly arrested 44 protestors, yet most were released after a few hours without charge. The Russian tanker nevertheless managed to deliver its Arctic oil for consumption in Western Europe. ‘While Russia requires icebreakers to escort ships transiting the Northern Sea Route’, observes Bennett ‘it certainly didn’t ask Greenpeace for its escort services in the North Sea. Be that as it may, the protest still successfully corralled Mikhail Ulyanov in Europe’s largest port. Such unwanted escorts are likely to continue – at least until authorities detain all of Greenpeace’s ships. Welcome to the new, footloose era of Arctic oil and environmental protest’ (Bennett 2014b, no page). The diffuse and enclosed nature of oil and gas pipeline networks makes it difficult to locate one particular spot to protest, especially as refineries and depots are often in highly secure areas. Yet the maritime transport of hydrocarbons creates two accessible protest sites: extraction and delivery points. Since both locations are usually in or near water, it is easier for protestors to approach these sites given that they are not fenced off as they might be on land. In the case of Russia's Prirazlomnaya project, those two sites are the floating oil rig in the Pechora Sea and the port of Rotterdam (Bennett 2014: no page).

There is thus a game of logistics and counter-logistics, involving material power but also laden with symbolism with the eyes of the world's media on the Arctic. Environmental activists look to exploit points of vulnerability, 'hacking' the material logistics network we might say and the exhibitionist or performance-like journeys of Gazprom, which are as much public spectacles aiming to demonstrate the feasibility of moving oil through the Arctic and thus attract further interest, development and investment. Greenpeace's logistics manager explained to me: 'we look for point of contact, whether that be a story, a conference, or a delivery of oil'. He continued 'we choose which level of attack – for want of a better term – we think will work' (interviewInterview E).

**Conclusion**

The preceding discussion demonstrated the ways in which the presence, absence, control and disruption, of routes, is central to the conduct of geopolitics. The affordances provided by ocean routes and the technologies which help enact them, continue to make a difference in processes of contestation. The establishment of paths enable power to travel but also fragments and carves open the territorial units which underpin geopolitical rivalries. Routes fragment and recombine territories, and demonstrate the ways shifting geographies and technologies mesh with shifting political, economic and societal 'landscapes'. Anthropogenically-induced geophysical changes in the Arctic involving actual and likely further reductions in the extent and thickness of sea-ice are providing new affordances for the carving of routes, yet climate change processes and the state changes of ice volatilise and condition processes of geopolitical contestation, demonstrating the ways in which it 'is no longer about playing the great game of state rivalry; it is also now literally about remaking the playing field' (Dalby 2009: 4).

The contestation over the NSR and NWP bears resemblances with aspects of the unfolding dispute over the South China Sea. Both are exemplars of oceanic, Anthropocene geopolitics. The supposedly oil rich and strategically significant South China Sea is the source of an ongoing dispute between China, Taiwan, the Philippines, Malaysia, and Vietnam. Under UNCLOS legislation states may use the presence of islands in order to claim sovereign rights over stretches of sea space. In order to strengthen their territorial claim over disputed areas of the South China Sea, the PRC has embarked on the construction of a series of islands, on which military airfields and outposts are being built. Those drafting UNCLOS legislation in the 1960s could not have anticipated states able to engage in the wholesale 'terraforming' or construction of islands in order to bolster jurisdictional claims. Similarly, dispute over the Arctic passages involve changes to the Earth that would have been difficult to anticipate decades ago. Both cases reveal novel material emergences and rearrangements, resulting either directly or indirectly as a consequence of human activity, that undermine the assumed constants and supposedly solid ground on which international law is based.

As Alfred Thayer Mahan recognised over 100 years ago, merchants and militaries shadow one another. The chapter has also demonstrated the deep links between military and civilian shipping, logistics and resource extraction infrastructures. Contemporary economic activities in the Russian Arctic are anchored in Cold War science, military shipyards, and ports. Now recently developed oil and gas reserves and routes once more become shadowed by military forces and mobilities.  As we saw in chapter two militaries are major institutional consumers of resources such as oil and nickel; the presence of militaries in the Arctic can only be seen in this context, ensuring the protection and supply of the very resources from which they are constituted. Finally, the chapter documented ‘counter-logistical’ practices which attempt to exploit the same affordances, in such a way as to disrupt, the ‘fuel-and-energy complex’.

The next chapter examines the ways in which the ‘global Arctic’s’ mutable material geography frustrates taken-for-granted abilities to anticipate the future.. Much like the Arctic complicates territorial control as demonstrated in this chapter, so too does it frustrate efforts to control and ‘map’ the future.

## Chapter seven: turbulent routes and fragile futures

### Introduction

The last chapter examined processes of contestation surrounding the Northern Sea Route, arguing that the earth is not simply a stage on which human dramas play themselves out, but plays a key role in Arctic 'geo'-politics. This chapter examines some of the ways in which a mobile geography, characterised by shifts and surprises, scrambles many taken-for-granted abilities to anticipate the future. This moving geography refers not only to the Arctic's 'shifty' geophysical characteristics, but also to the shifting relations that link Arctic shipping activities to global patterns of resource extraction and cargo transportation (see chapter four). Twists and surprises are a salient feature of a world of 'global complexity' (Urry 2003). Due to its complex geophysicality, Arctic futures are especially difficult to map. As Gerhardt et al argue, 'Arctic materiality, stable in neither time nor place, complicates the ideal of permanence that underpins modern conceptions of sovereignty' (2010: 994). The possibilities for non-linear emergences are especially pronounced. Geopolitical, geoeconomic, and geophysical processes intersect in especially difficult to predict ways in the 21st century Arctic.

A world alive with novelty and risk produces 'opportunity niches' for technologies and techniques that 'see in advance' or help peer into the future. Rapidly moving spaces and situations have led to a proliferation of techniques which seek to map or disclose futures, such as climate change modelling, scenario planning and journalistic/academic 'pre-mediation' (Grusin 2010). Recent years have witnessed a proliferation in social science literature on the future, and contemporary work on the Arctic is typically concerned with the region's future(s), as it becomes reconstituted by the convergence of climate change and globalisation. As we briefly saw in chapter five however, projections can also be difficult to make for Arctic shipping activities, due to the relative lack of historical activity and experience operating in the region, and/or lack of available data on which to base projections, for instance for insurance and infrastructure planning purposes. If the Arctic is witnessing unprecedented change however, trend projections and extrapolations from existing patterns will be of limited use (Arbo et al 2012: 177).

The NSR witnessed a surge in traffic beginning in 2010, three years after 2007's dramatic melt of summer sea-ice, a global media event which, as well as producing a slew of 'catastrophist' narratives on the passing of climate thresholds or 'tipping points', set in motion expectations regarding improved accessibility for shipping and resource extraction. Media stories exclaimed: 'Global warming to open-up north-east Arctic tanker route' (Riddoch 2009), and following the even more spectacular melt of 2012, 'Melting ice brings Norway and Asia closer together' (Agence-France Presse 2013). In 2011 Russia's Ministry of Transport asserted that cargo transport through the NSR would reach 64 million tons by 2020. This forecast now seems wildly optimistic, but such pronouncements, made by the chief beneficiaries of increasing shipping activity along the NSR, are intended to 'not only describe a future but bring one into being' (Tutton 2012: 1721). Whether they succeed in doing so is another matter.

Whilst traffic doubled along the NSR every year between 2010 and 2013, transits plummeted by a massive 80% in 2014 (Pettersen 2014). Cargo along the NSR declined from 1.3 million tons in 2013 to 300,000 tons in 2014, with only 31 recorded transits. By October 1, 2015 less than 100,000 tons had been transported between Asia and Europe along the NSR. The NSR seems to have 'frozen-up' just as abruptly as it emerged. The causes for this are attributed variously to the collapse of oil and commodity prices, to the cascading effects of sanctions imposed by NATO on Russia in the wake of Cold War 2.0, to the failure of sea-ice to recede in the manner predicted, or some combination thereof. The first part of the chapter examines the conditions which combine to make Arctic shipping futures so uncertain or fragile. The second part of the chapter examines a range of efforts to map, model or come to terms with uncertain futures.

**Shifting sea-ice**

Efforts to carve an Arctic alternative to the congested and piracy plagued Suez Canal through the Arctic continue to be frustrated by sea-ice – a particularly recalcitrant material 'actant'. Whilst ice is sometimes figured in terms of stasis, as cessation of movement, or in shipping lingo 'obstacle to navigation', it is actually the dynamism of sea-ice, its variability which poses the most formidable of obstacles. The seasonal nature of the NSR already poses problems for shipping and resource extraction. Most obviously, it is very difficult to recuperate the costs involved in the construction of expensive ice-class vessels when they can only be used for six months of the year. The cyclical rhythms of the seasons clash with the rhythms of investment. As Johnson argues 'there is no 'just doing business' in the Arctic. The turnover times of capital must be somehow reconciled with the materiality of the Earth's turnover times – annual cycles of temperature, melt and freeze, light and dark that reach their extremes in the Poles (2010: 843). The inherent volatility of sea-ice especially is being exacerbated by Arctic climate change processes. Melting is not following a 'smooth' or linear downward trajectory, but instead demonstrating high levels of inter-annual variation (Rampal et al 2009). As a prominent climate scientist explained to me:

> One or two scientists got a little bit over excited in 2007 and 2012, not many literally just one or two, who made some rather outrageous forecasts, I think the rest of the [climate science] community realised that it was a bit of an odd year, the weather was particularly conducive to melting ice those years, and

> there's no indication that those weather patterns were going to continue every year, other scientists said no hang on, this isn't an indication of where things are going, 2013 and 2014 were quite a bit above 2012 for example, and so my view of this is that there is a long term downward trend, there is a lot of superimposed variations, which can last years or perhaps a decade or so, it's a long term downward trend, sometimes you'll see more rapid decline, other times slower, other times no decline, as these variations will be modulating the trend; it's a bit like the stock market, with many ups and downs along the way!; the physics of the situation mean that rising temperatures will mean melting ice but how and where this happens we do not know in enough detail at the moment (interview G)

The behaviour of sea-ice – its patterns of melting and freezing – is incredibly difficult to model, due to its complex intersections with other climate elements and processes, the difficulty its volume or thickness poses for remote sensing techniques, and the way numerical climate models (GCMs) do not operate at a fine enough level of granularity to capture important sea-ice dynamics (Day et al 2014). I return to discuss climate modelling below. The fluctuating fortunes of the NSR overlap, albeit imprecisely, with changes in the overall extent of Arctic sea-ice. 2007 and 2012 were low ice years, but then the ice made a slight recovery in 2013 and 2014 (a recovery 'climate sceptics' were quick to exploit). The high level of inter-annual variability exacerbates these problems yet further, as the start and finish date of the shipping season cannot be predicted ahead of time. Indeed, Anthropologist Hastrup documents the ways in which even the intimate knowledge of sea-ice embodied in Inuit hunting communities in Greenland, for whom this knowledge is a pre-requisite for survival, is being stretched to breaking point, as 'it is impossible to forecast even the near future of the ice, and concomitantly of the hunt' (Hastrup 2013: 79).

The navigation season opened two months later in 2014 than in 2012, leading one expert, Mikå Mered, CEO of Arctic consultancy Polarisk, to declare: "We are two months late compared to 2012 and many planned cargo and passenger transits are currently being cancelled. There's too much ice and it seems that the Arctic ice extent will reach a decennial record high this year. I expect this will generate scepticism on the future economic viability of the route and the related investments already announced by the Arctic littoral countries" (Mered, cited Shettar 2014: no page). Others however disagreed that sea-ice played a significant role in 2014's steep decline in traffic. When I asked an expert in Arctic logistics about the drop in traffic, he was unequivocal: 'ice is no longer a problem… lack of cargo is the problem' (interview B). It is difficult to know for sure the role of ice in 2014's drop, but it may be that the perception or expectation of more difficult conditions played a role in cargo and vessel owners' decisions to not send their cargos via the NSR.

Yet overall the fluctuating characteristics of sea-ice, and the difficulties this poses for anticipating the future, plays an important role. One of the main advantages of the NSR is that it provides a potential 15-day reduction in journey times between the major container ports of Europe and Asia, and there were expectations amongst some in the shipping community that as the ice melted container shipping would become feasible (for a good example of this early excitement, see Verny, Grigentin 2009). The establishment of container networks through the Arctic is key to establishing a fully-fledged trade route, characterised by looping rather than simply one-way journeys, where ships deliver cargo to one port and return in the other direction with another. A circumpolar geography is in theory ideal for the operation of so-called 'pendulum routes' travelled by container ships. Indeed, one could imagine container ships travelling in loops through or *around* both the Northern Sea Route and the Northwest Passage, serving ports along the way. However, major cities to service, and deep-water ports for container ships to dock at, are few and far between in these remote areas and shallow waters. The NSR passes through shallow waters, meaning that constructing deep-water ports poses problems. Yet at the same time these shallow waters are also why the area is rich in hydrocarbons, and the NSR's proximity to known and believed deposits of oil and gas is one important reason why there is more interest in developing the NSR than the NWP (Ostreng et al 2013).

Whilst remoteness poses one impediment to the establishment of container shipping networks, the main obstacle remains sea-ice's highly variable patterns of freezing and melting, which wreak havoc with the 'just-in-time' character of the container shipping system. As discussed in chapter three, containerisation is based on fine-grained temporal coordination, where products and components, manufactured across many different locations, are brought together at the last minute so as to minimize the amount of time they remain immobile. The JIT system is characterised by a combination of flexibility and rigidity. On the one hand, it can respond to hard to predict shifts in product demand; on the other scheduling constraints are much more severe than in warehouse and inventory-based forms of manufacturing, and even minor delays can have cascading and hugely disruptive consequences (Neilson 2012: 331). The JIT system is precariously poised, and involves a temporal orientation whereby the future exists as 'a territory to be colonised or conquered' (Giddens, cited Rickards et al 2014: 589), where everything must unfold according to plan, and where surprises must be avoided at all costs. The difficulty in predicting patterns of freezing and melting means sea-ice scrambles the operations of the JIT machine, translating into unpredictable and costly delays. Nevertheless, in 2013 the 19,000-ton *Yong Sheng*, operated by China Ocean Shipping Company (COSCO), became the first container ship to make its way through the NSR, journeying from China to Rotterdam. Whilst container infrastructure does not presently exist, it is being imagined, with one of my interviewees conjuring images of future 'floating container terminals' that would serve container ships to compensate for the lack of deep-water ports (interview A).

As we saw in the previous chapter, ice also scrambles the state system of sovereign possession, which is based on a land/sea binary, and complicates efforts to attribute jurisdiction over the passage. But it is not just that ice exists in a precarious state between the solid and the liquid, but also that 'yesterday's ice is tomorrow's water' as Gerhardt et al (2010: 994) write. The complications caused by ice are temporal as well as spatial. As we saw in the previous chapter much of the NSR lies more than 12 nautical miles from Russia's coastline (the threshold within which the United Nations Conventions on Laws of the Seas customarily grants littoral states jurisdiction), but article 234 of UNCLOS legislation stipulates that states may extend jurisdiction beyond this limit in cases where bodies of water are 'ice-covered for the majority of the year' (UNCLOS 1994: article 234). Even now there is little agreement regarding the precise meaning of 'ice-covered for most of the year'. But Russia's already tenuous legal hold over the passage becomes ever more precarious as temperatures increase and as this ice melts. Indeed, the variable character of the melt means attributions of sovereignty over the NSR become even more uncertain and open to contestation. A least according to the letter of maritime law, one moment the route could be deemed to belong to Russia, the next deemed 'international'. The classificatory schemas which cut-up and infrastructures which 'sort out' the world, at no matter how fine-grained a-scale, often become undone by matter's capacity for transformation, a capacity starkly embodied in water (Strang 2004; Peters, Steinberg 2015). To 'sort things out' (Bowker and Star 2000) presupposes the stability of the 'things' so sorted. But water shifts 'fluidly' and often abruptly from solid, to liquid to gaseous states. Ice's propensity to shift, and sea-ice's complex intersections with other processes, make it an apt metaphor perhaps through which to grasp contemporary global sociotechnical processes, marked by interconnections and high potential for turbulence, where events occurring at one location can alter the fortunes of a range of other events occurring far-away, and where tipping points and phase transitions can lead to unexpected freezes and 'meltdowns'. Perhaps the paradoxes of ice capture the contemporary world more than say Bauman's metaphor of 'liquid' modern processes (Bauman 2000).

**Shifting resource winds**

The contemporary NSR can best be understood as an experimental, trans-national but Russian-controlled Arctic resource and cargo mobility nexus. The development of shipping along Russia's Arctic coast is tied heavily to oil and gas extraction in the Russian Arctic, and to the extraction of minerals like nickel and iron ore. Events that affect the relative profitability of these resources have consequences for shipping, as not only do resource extraction projects need routes to deliver their product to markets, but also generate significant shipping activity in the form of seismic and research vessels, as well as ships delivering supplies and equipment to both offshore and onshore sites. Interest in Arctic resources depends on the global prices of commodities (Dicken 2011: chapter eight; Bennett 2014d). For instance, the degree to which oil companies find the region attractive rests on their political and technological access to potentially cheaper resources, such as tar sands and shale oil. Following the publication of the US Geological report in 2008, which estimated that the Arctic could hold as much as one third of the world's remaining oil and gas deposits, and amidst worries of stagnating capacity and political risks in the 'petro-states' of the Middle East, Africa and South America, where the spectre of 'resource nationalism' looms, and financial speculation that drove oil prices to nearly $150 per barrel, the Arctic became an attractive site for exploration (Bridge, Le billon 2012). However, as global oil prices have fallen and cheaper sources of hydrocarbons are to be found elsewhere (particularly significant has been US shale gas), the Arctic has become less attractive to major Western oil companies. The motivation to explore shale gas, paradoxically, was triggered by high oil prices. According to an interviewee:

> Shtockman has been put on hold. Cost of gas was too low in world market, due to shale gas in the US, and that has spread to other parts of Europe, and this has made countries like the US realise that their reserves of gas are much higher than they thought; originally were going to liquefy NG, initial thinking was that US would be major market… But that market vaporised. But the market has shifted from US to Japan, but the price is still low (interview A).

The demand for mineral resources from the Arctic likewise depends on the relative profitability of these resources. Iron ore from mines in north Norway and Siberia were an important resource transported across the NSR to the steel mines of China in the first half of the decade. For nearly a decade, China's burgeoning steel industry produced more than ten times the steel of Japan, the world's second largest producer. But as domestic demand slowed and China attempts to curb the air pollution associated with steel production, the Chinese steel industry has gone into recession, with many abandoned steel mills now being demolished to make way for farmland (Campbell-Dollaghan 2014). Thus, the steep drop in demand for iron ore – one of the chief ingredients in steel – precipitated the major drop in cargo moved along the NSR 2014 (interview C), an event that illustrates the synergies that already bind Asia with the onshore and offshore Arctic.

**Shifting cargoscapes**

Traffic along the NSR is also affected by the relative ease and profitability of moving cargos via other routes. Russia’s largest non-state owned gas producer Novatek were transporting gas condensate to a terminal near Murmansk, whereupon the gas would be transformed into products such as naphtha, jet fuel and heating oil, and then transported via tankers owned and operated by Russian energy shipping company

Sovcomflot along the NSR to terminals in Japan and South Korea (interview B). However, following the opening of a new gas terminal in the Baltic region at the end of 2013, the so-called ‘Ust-Luga Complex’, which processes stable gas condensate into petroleum products, the condensate and refined products are now being moved to Asia from the Baltic Sea and then through the Suez Canal (interview B).

In addition, the costs (or ‘freight rates’ in shipping industry lingo) for very large vessels going through the Suez Canal are at present very low, thus meaning cargo owners are more likely to send cargos via Suez, even if the NSR is shorter (interview B). This situation is only likely to be compounded by the recent expansion to the Suez Canal, which has both widened its existing lanes and added a new one (Savitzky 2015). Indeed, current conditions in the freight market are leading some shippers and cargo owners to send bulk cargos via the Cape of Good Hope, which Suez supposedly replaced, as whilst this route is much longer, it has no restrictions on the size of vessels (Casey 2016). Whether the dictates of scale or speed dominate, depends significantly on the price of oil. Using a short-cut was seen as a way to save on fuel costs when oil prices were relatively high, and high oil prices drove the development of Arctic oil and gas, which in turn drove the development of the NSR. As prices dropped in 2014, the incentive to use short-cuts disappeared as well as there being less interest in Arctic oil and gas (Platts 2016).

Uncertainty itself is a major obstacle to further development. Shipping lines and exporting states value above all reliability and consistency in transportation. To less fanfare than many of the journeys made across the NSR, a cargo train made its way across over 15, 000 miles from China to Spain in 2015. The train was traveling across, and helping to create, the so-called ‘overland Silk Road’, a new version of an ancient trade route being developed by China. Unlike the NSR, the route runs over terra firma, and could well provide a more stable alternative both to current chokepoints and to the NSR (Bennett 2014a). Planned capacity upgrades for the Panama Canal could also prevent traffic from being rerouted through the NSR.

Bunkering fuel accounts for 70 percent of a vessel's voyage cost. fluctuation in oil prices therefore have a direct impact on overall operating expenses and profit margins. Shorter transit times mean less consumption of bunker fuel, which in turn allows ship owners to realize substantial savings. In June 2014, oil prices were at a peak of approximately $115 per barrel, and such prices quickly eroded expected profit margins. Coinciding with this hike in oil prices, 2014 witnessed an increase in the number of permit approvals by Russia for journeys through the NSR.  This increase is not coincidental as the relatively high cost of oil meant that shipping companies were willing to attempt cost-reduction measures such as utilizing the NSR. But between July 2014 and January 2015 the price of oil plunged (World Bank 2015: 11-22), and although 600 permits were issued by the NSR administration authority, the number of vessels completing NSR transits declined enormously. From June 2014 oil prices fell continually, and there was less incentive for companies to adopt cost-saving measures. Combined with the on-set of the winter season, this meant that traffic slowed to a stop after September 2014 (McMillan 2015)).

**Geopolitical turbulence**

Russia's annexation of the Ukraine has also reshaped the possibility space within which this Arctic resource extraction and cargo mobility nexus unfolds. The downing of passenger plane MH17 over the Ukraine allegedly by Russian backed separatists, turned out to be a tipping point in global politics, with consequences for the Arctic. It has led to the imposition of so-called 'targeted sanctions' against figures thought to be close to Russian president Vladimir Putin. The effects of these sanctions have not remained localised in specific figures and their immediate interests but spilled out over a wider territory, affecting especially off-shore Arctic energy projects, and thus indirectly transportation. Russia cannot develop its oil and gas reserves in the Arctic without the technology of the major Western oil companies, hence the joint ventures between Russian and Western firms. Sanctions have had reverberations for the Yamal Megaproject, owned by a consortium made up of Novatek, French company Total, and the Chinese National Petroleum Company. The project is not set to commence production until 2017, but nonetheless generated significant shipping activity, bringing construction equipment, workers and supplies through the NSR. This LNG plant is considered one of Russia’s most strategic energy initiatives. The project is in danger of being disrupted or halted by sanctions that block financing deals and the supply of drilling equipment – measures deliberately intended to hit Russia’s plans to exploit its offshore Arctic and ‘tight’ oil reserves

. The US has restricted Rosneft and Novatek’s access to capital markets, along with imposing a ban on the transfer of technologies used in Arctic, deepwater and shale exploration – areas crucial to the development of future Russian hydrocarbon development. The US holds most of the licenses for the liquefaction technology central to the development of LNG facilities, and a ban on its transfer to Russia could pose serious problems for the Yamal Mega-project (Chazan, Farchy 2014: no page). The Yamal Mega-project consortium is now exploring creative practices of financial ‘offshoring’ (Urry 2014), in attempts to ‘route around’ the sanctions (Patel 2014). The sanctions have also affected Rosneft’s partnership with Exxon Mobil in the Kara Sea.. Sanctions may reinforce trading links between Russia and Asia, with Rosneft’s chief executive proclaiming: ‘If the Germans do notwant to deliver [drilling equipment and pipe systems], we will just buy from South Korea and Japan’ (Sechin, cited in Chazan, Farchy 2014: no page).

Other firms affected by the sanctions include Helsinki based shipyard Aker Arctech. The shipyard is the world’s leading producer of ice-breakers and ice-class vessels.

The Helsinki yard, founded in 1865 and renamed Arctech in 2010, has built 60 percent of the world's icebreakers – most of which are used by Russia, including in offshore energy production activities. While standard shipbuilding has largely moved to Asia, Arctech's is one of a few shipyards left in Europe, due to its niche status as manufacturer of ice-capable vessels. The company's managing director said: "There are lots of details but no concrete list for building an Arctic vessel, it's more about tacit knowledge" (Mustamaki, cited in Rosendhal 2015: no page). The shipyard constructed most of Norilsk Nickel's fleet, and since the start of the decade, and the excitement surrounding increased shipping and resource extraction activity, enjoyed a boom in business. The shipyard is far from the Russian Arctic, but nevertheless might be seen as functionally integrated into what we might call the NSR as transnational assemblage (in contradistinction to the NSR as legal entity defined in Russian legislation). The yard is currently building six vessels, four for Russian state-owned shipping company Sovcomflot and one each for the Russian and Finnish transport ministries (Rosendhal 2015). Yet in 2013 the shipyard was acquired by Russia's state-owned United Shipbuilding Corporation (USC), which was added to the list of interests targeted by the sanctions. The Nordic region's biggest bank Nordea closed Arctech's account in 2014 as a result of the sanctions. The shipyard has opened new bank accounts, but accessing finance now takes more time, and U.S. and EU sanctions against the company's Russian clients could complicate orders in the future. Paradoxically, the sanctions could also hinder Barack Obama's plans to expand the US's presence in the Arctic. Ice-breakers are key to moving though and exerting force over Arctic space. Establishing and bolstering geopolitical 'presence' in the remote and sparsely populated Arctic, appears to be dependent – more so than other places on Earth – on the ability to move through it (Rosendhal 2015).

Russia closed its airspace in response to the sanctions, leading some to speculate that it could also close the NSR (interview C). However, closure of the passage to international traffic would be contrary to Russian interests, according to my interviewee from the Tschudi Group. Unlike air-space, the NSR generates transit fees. But my interviewee conceded that fears of *possible* closures could be affecting cargo owners' decisions to use the NSR:

> the [ships and cargo] owners could save a little bit of money going through the Northern Sea Route, but then they might think 'hey we never know what the Russians might get up to… you know 'I do not want to get stuck up there with my ship if the ice-breakers decide not to come and escort me'… or that Putin could close the routes around Novaya Zemlya [where there is a big military presence]. I mean you never know what the Russians are up to – that's what the cargo owners could think, and decide 'forget about the Northern Sea Route I want to go via Suez, its more predictable'. This is all based on rumours of course, but yes, there is more uncertainty now (interview C)

According to the managing director of the Centre for High North Logistics: 'We're ending the era of foreign demonstration voyages that were promoted by Russia. Now it seems that reality is kicking in' (Gunnarsson, cited in Doyle, Scrutton 2015).  We have seen how unanticipated geophysical, geoeconomic and geopolitical events have combined to thwart early expectations of increased traffic along the NSR.  Just as quickly as the NSR re-emerged, so it seems to be fading away. What may have been a tipping point for the NSR, may just have been a flash in the pan, random noise eagerly consumed by a media environment obsessed with mapping emerging trends, or domesticating the future in the form of 'the next big thing'. The following section examines a range of efforts to map futures or 'see in advance'.

**Mapping futures**

Perhaps the most significant and authoritative of contemporary forms of seeing in advance are climate change models, especially numerical General Circulation Models

(GCMs). However, only a quarter of models anticipated the rate of sea ice loss comparable with that actually observed by satellites since 1979, according to the Intergovernmental Panel on Climate Change (IPCC: 2014).

> It is difficult to think of a more complicated physical system than Earth's climate. Governed by a combination of the laws of fluid dynamics, thermodynamics, radiative energy transfer and chemistry, the climate system is composed of the atmosphere, the oceans, ice-sheets and land. Each of these four subsystems is coupled to each of the other three, through the exchange of immense quantities of energy momentum and matter… Nonlinear interactions occur on a dizzying range of spatial and temporal scales, both within and between the subsystems, leading to an intricate and delicate network of feedback loops (Williams 2005: 2931)

For the complexity of the climate system to be manageable, climatologists must 'slice it up' or break it up into its constituent parts. The complexity of the climate system is addressed by examining the convergence and divergence of isolated phenomena, such as land surface temperatures, sea level rises, and reductions in the polar ice-caps. The granularity of the cut is significant. The scale of data excludes important features of the climate system as envisaged in real time such that significant small-scale processes and interaction mechanisms disappear from view, Simulations smooth out the variation of data ignoring fluctuations which are too small or fast to be modelled (for instance gravity waves, convective clouds and small-scale turbulence. See Williams 2005: 2933-2935).

> all of these features are known to be key aspects of the climate system, owing to their non-linear interactions with the resolved scales, and yet they are too small to be explicitly modelled. The presence of such critical unresolved

> processes must surely be one of the most disheartening aspects of climate modelling (Williams 2006: 2933)

Arctic sea-ice in particular poses major challenges for climate change modelling. Many of the physical processes involving interactions between sea-ice, the ocean and the atmosphere occur on finer scales than models are able to simulate. ‘Melt ponds’ are a good example (Flocco, Feltham 2007). These pools of meltwater on the surface of the sea-ice affect how much of the sun’s energy is reflected, and how much is absorbed by sea ice. Ridges that develop when ice floes collide make the surface rougher and can also affect the interactions between the ocean, sea ice and atmosphere. Scientists must simplify the effect such processes have on sea-ice using mathematical equations to represent these complex physics, in a process known as *parameterisation*. One reason for the lack of knowledge is that the processes are relatively novel research areas and yet to be subject to detailed study. But the most significant challenge is that models must be tested against ‘real-world’ observations, and at the moment, those observations do not exist. Once again the ‘remoteness’ of the Arctic is key here. Scientists need in-situ data about physical processes occurring across the whole Arctic, further increasing the magnitude. Another problem that sea-ice poses for climate modelling are the inherent difficulties in measuring or registering ice’s *volume* or thickness, through the remote sensing devices (mostly satellites) which have otherwise enabled scientists and societies to generate so much data about sea-ice’s area, extent, or location. Ascertaining the precise thickness of sea-ice in the present, is key to being able to make accurate forecasts regarding its future extent and location (Day et al 2014: 7571-7574).

The IPCC use between 5 and 10 climate change models, some of which have been more accurate than others in predicting change processes - up until now. But what currently are the most accurate climate models will not necessarily still be so in say a decade. As the sea ice cover and climate in general evolves, different physical processes assume more or less significance. And so according to Feltham: ‘unless you capture the physics behind those processes, you can’t predict how they’re going to change in future” (Feltham, cited Pidcock 2014: no page). Although numerical models are apt at rendering regularities, they are far less suitable for singularities, for instance rapid climate switches, or tipping points. Numerical models are good at dealing with trends and established patterns, rather than surprises. The triggering mechanisms for climatic changes are thought to be rare ‘extreme’ events. Such events, being on the time-scale of seasons, are fundamentally unpredictable.

It has been said that climate modelling is beset by the paradox that as knowledge of climate processes increases, so does uncertainty. As climate scientist Kenneth Trenberth puts it: ‘More knowledge, less certainty (Trenberth 2010), as the ability to probe the word reveals processes that exist, and that are understood to make a difference, but whose workings remain poorly understood. Slicing the climate-system into discrete components – in no matter how high resolution or fine granularity – misses the dynamism that elements display when in motion. Even without accounting for the responses of sociotechnical systems, the complexity of interactions between earth processes such as ice sheets, sea-ice, permafrost, ocean vectors etc. make predictions very difficult. Components of the cryosphere such the Greenlandic ice sheets, Arctic sea-ice and permafrost represent key sources of uncertainty in climate change models and the feedback loops – or abrupt changes in climate they might set in motion.

I put Trenberth’s formulation regarding the recursive links between knowledge and uncertainty, to another prominent climate scientist, a specialist in Arctic climate change processes:

> we’ll make certain strides forward and we’ll be more confident about certain things as our models get more complex; but there will still be some inherent uncertainty because our models will never be perfect; physics says that the earth will warm if we have more C02, its just a matter of how much and where, which we’re getting a much better handle on, but were not perfect yet by any means (interview G).

There is a tension in the extract between on the one hand, an acknowledgement of the impossibility of ‘perfecting’ modelling processes, of the inherent limitations of models, and inability to ever fully be able to capture the physics of a world-in-motion. On the other hand, the phrasing ‘not *yet* perfect’ indicates an expectation of progressively refined and more accurate climate knowledge, as if by increasing the granularity of representation uncertainty could be eliminated. Yet there are alternative approaches to climate change modelling which rather than try and eliminate or reduce uncertainty through increasingly fine-grained modelling, attempt to use uncertainty productively. One suggestion involves adding random ‘noise’ to models in an attempt to mimic the impacts of the difficult to model or unresolved processes. The stochastic or non-linear phenomenon in climate change remain the main challenge in climatology, and adding random noise is known to have improved the performance of the model (Hastrup 2013 20): ‘it is truly remarkable that random noise – the very epitome of the unknown and the unpredictable – can actually increase the performance of models’ (Williams 2006: 2933-34). Uncertainty here is not eschewed, but to the contrary mobilised as a resource to help model and map futures. This is the productive role of noise, uncertainty or turbulence.

What about mapping social, or sociotechnical, futures? A rapidly shifting world and a rapidly changing Arctic invite speculation regarding the future. In recent years, there has been a proliferation of social science literature on the future, and contemporary work on the Arctic is typically concerned with the region's future(s), as it becomes reconstituted by the convergence of climate change and globalisation. The more uncertain the future the more discourse is produced to plug the gap such uncertainties create. But as Arctic anthropologist Nuttall argues 'how the future looks depends on where one is standing at the present' (Nuttall 2012: 102). Many accounts presume the future will simply be a continuation of current trends. There is a tendency by media, academics, experts and visionaries to project forward from present events and follow emerging trends through to their logical conclusions (Arbo et al 2013); this is a hyper-sensitivity to the 'shocks' or unexpected events which characterise the present, a way of responding to turbulence by following linear trajectories into the future. As described above many reacted to the 2012 melt by presuming a steady future of progressively less summer sea-ice and hence more shipping traffic. When traffic declined by 80 per cent in 2014 many analysts were quick to close the door on Arctic shipping. Other examples include the planting of the flag under the North Pole seabed, which led to a slew of journalistic, popular and academic work pronouncing that there would be a militarised 'scramble' for the Arctic and its resources (see especially Howard 2009; Fairhall 2010 Sale, Potapov 2010). Yet these projections appeared too hasty following a number of high profile examples of inter-state cooperation, and many analysts then proclaimed that Arctic futures were likely to be characterised by relative peacefulness. However, following the Ukraine crisis things quickly took another twist, and as relations between Russia and the West 'thawed' the Arctic has witnessed a build-up of military activity not seen since the Cold War.

Accounts which attempt to anticipate futures do not stay separate from, but can have performative (or counter-performative) effects on the worlds they describe, which increases overall complexity. In recent years, we have seen the proliferation of attempts to predict social or technical futures which are self-consciously performative, seeking to pre-empt or amplify emerging trends. The pre-emption or amplification of emerging trends is a salient aspect of contemporary cultures. This occurs for example, with online recommendations which guide prospective consumers down established paths, attempting to pre-empt purchasing choices. Such attempts to amplify or pre-empt existing trends are also employed in the design of infrastructures, and such forms of anticipatory design are being employed by NSR promoters and enthusiasts.

A key organisation is the Centre for High North Logistics (CHNL), partly funded by the Norwegian state and partly by the Tschudi Group (discussed in chapter four). CHNL are an example of a ‘promissory organisation’ (Pollock, Williams 2010) which provide consultancy to firms and serve as a ‘knowledge-hub’ for Arctic logistics. They provide what Pollock and Williams call ‘organising visions’ of Arctic shipping futures. I carried out an interview with the managing director of CHNL in 2012 – at the peak of excitement regarding the ‘opening’ of the NSR. The walls of his office, in the same building as the Barents’ secretariat in Kirkenes, Northern Norway (200 miles north of the Arctic circle), were plastered with maps and diagrams showing the location of potential oil and gas reserves and of ports along NSR. CHNL’s director was involved in a working group exercise during 2010 which sought to explore possibilities for the placing of a transhipment hub, where the cargo from ice-capable vessels carried along the NSR could be put onto vessels more suitable for operation in normal waters, significantly saving costs (vessels made for operation in ice-waters are uneconomical in open waters). The existence of a nearby transhipment hub is seen as crucial in attracting more transits, especially container shipping, along the NSR. Pointing up at one of the maps in his office, he explained that infrastructure design should not merely reflect current usage, and not even respond to anticipated future usage, but should be designed to actively invite or produce the desired traffic increases.

> I have always been promoting the idea that say based on current trends, why do not we model or simulate what kind of activity we want to see in 30 or 40 years and then see what kind of infrastructure… what kind of cargo would be transported from where to where, what kind of search and rescue… we need to think out of the box and dare and simulate what kind of activity we might see and even what kind of activity we want to see in the Arctic in next 30 or 40 years (interview A).

> Are we going to be transporting containers, or cars from Japan… so are we talking about 10 million TEUs or 100 or 200 million, so if we are moving cars or all sorts of cargo, Suez can't take any more, what is involved in container transport; container traffic relies on transhipment hub, so if NSR is to act as container route, then we need to build a transhipment hub, where shall we build this transhipment hub - these discussions are already taking place (interview A).

Yet despite this, as of late 2015, none of the upgrades and plans outlined had been put into practice. The investments and upgrades promised by the Russian state have not as yet been forthcoming. The Kila project in Kirkenes discussed in chapter four has yet to develop, although I was told the project has not been abandoned.

The presence of surprise events or discontinuities mean that efforts to model futures based on past trends will only be of limited use. In recent years, so-called . scenario thinking and planning has emerged as a way of dealing with the discontinuous and the emergent, and are used across a range of areas including the social sciences. The latter work of Urry frequently employed scenario thinking to imagine post-car, post-oil as well as other 'possible, probable and preferable futures' (Urry 2011: chapter nine; 2013: 166-202) Scenarios do not seek to predict the future but present plausible alternative views about how the future might develop. Importantly, scenario-thinking recognises that many futures are possible, and to some extent already in the making. Scenarios have military origins, and find particularly fertile application in areas such as imagining Arctic futuresIn 2009 the Arctic Council funded a study on Arctic shipping futures, the AMSA Arctic Shipping Report (AMSA 2009). The report outlined a number of scenarios where the main axes of variation were the strength of Arctic governance structures, and global demand for oil and gas resources (both presented as a weak/strong binary). The scenarios recognise the ways in which Arctic shipping is inextricably linked to resource development which in turn is linked to social and economic events and processes occurring elsewhere. Included in the scenarios are events such as a global pandemic of avian flu which has knock on effects for Arctic resource development and shipping, military show-downs between China and India which spills into the Arctic, and the occurrence of a major oil-spill in the region which, paradoxically, serves as the impetus for the instantiation of stricter environmental regulation.

Scenarios attempt the impossible which is to know the unknowable. They of necessity therefore deal with 'known unknowns' rather than 'unknown unknowns' (i.e. genuine novelty). Scenarios simultaneously open and close futures, and make 'non-innocent' assumptions regarding what kinds of changes are/not likely. Each of the four AMSA Arctic shipping scenarios takes as given the continuation of the present economic model and continued carbon emissions. None of the scenarios take into account the possible emergence of 3D printing systems which could have massive implications, potentially eliminating much cargo shipping and associated carbon emissions, and dramatically reconfiguring the entire system of production and consumption, as objects could be 'printed' in consumers' homes, rather than travelling by sea (Birtchnell and Urry 2015). Yet as the introduction to the Arctic Council's AMSA report states 'the test of a good scenario is not whether it portrays the future accurately, but whether it enables an organization to learn and adapt' (AMSA 2009: 3). Rather than disclose a specific future or event, scenarios are intended to capture or evoke a sense of the emergent or discontinuous itself, and foster an affective state of preparedness or heightened ability to respond. Scenarios are also performative framing acts, those outlined in the AMSA report present visions of the world which necessitate an institutionally strengthened Arctic Council and 'justify and legitimate further interventions by the Arctic Council' itself (Dodds (2012: 197-200).

Efforts to envision the future (of the Arctic) are of necessity caught-up with efforts to create or carve it. This study has largely avoided making predictions or creating 'scenarios' of the kind envisioned by AMSA. We have already seen how history and existing trends are a poor guide to what will emerge in future. Yet even scenarios thinking/planning is too indebted to military-logistic ways of envisioning and acting on the world, ultimately rooted in the same 'command-and-control' model that seeks to make the future governable, or to domesticate it. Scenario thinking/planning also tends to divorce envisioned futures from action underway in the present, whilst this study is concerned with the messiness of an actually existing NSR.

**Conclusion**

According to George Monbiot: 'to know what comes next has been perhaps the dominant aim of materially-complex societies' (2014: no page). 'Materially complex' societies are those characterised by high degrees of sociotechnical interdependence, or what archaeologist Hodder simply refers to as entanglement. Paradoxically however, societies have become so materially complex, that this now makes 'knowing what comes next' more challenging perhaps than ever before in human history. As Monbiot explains early humans or hominids, had to navigate environments that were 'shimmering with surprise and hazard. Their survival depended upon reacting to the barest signals: the flicker of a tail in the grass, the scent of honey, a change in humidity, tracks in the dust' (Monbiot 2014: no page). As well as being on the look-out for predators, pre-Holocene humans and hominids had to be highly attentive to shifts in the weather, as weather patterns fluctuated dramatically. As Monbiot explains, 'ours was a rambling and responsive existence, in which by comparison to the way we live today, we had little capacity or inclination to impose our will on the world, to lay out a course of action and to follow it without deviation or distraction'. Early humans or hominids, tended to be focused on day-to-day life, or the immediate present, rather than the future. Anthropologists of Arctic peoples have documented the ways in which this attentiveness to surroundings is a pre-requisite for survival. Describing his ethnographic research in Greenland, Nuttall (2012) describes the ways in which Inuit consider that seeing the world around them as one of constant motion and movement, of uncertainty, flux and surprise, is a fundamental pre-requisite for survival (see also Hastrup 2013).

In many ways, the contemporary has come to resemble once more that of our ancestors, a world alive with potential tipping points, which present both opportunities and risks. As technologies, times and spaces become ever-more entangled (Hodder 2012), and as the range of materials, people and processes brought into combination and recombination proliferate, so does the potential for novelty, innovation, or unexpected events (Arthur 2010). Predicting or planning for the proximate future is becoming more difficult in a world marked by increasing material complexification. Arthur maintains that it is now effectively impossible to know what technologies are just around the corner, in contrast to a century or half century ago, when technology evolved at a slower pace; by the same token it is difficult to know the new risks that result when materials from across arbitrary 'natural' and 'artificial' divisions mingle, or when things from some 'ecologies' are introduced into 'alien' environments, as when ships and their emissions invade the Arctic.

Braun argues that: ‘in the Anthropocene the shape of things to come is increasingly seen to be nonanalogous with what existed in the past’ (Braun 2015: 239). The longevity that characterises the architectures, infrastructures and materials in the Anthropocene (i.e. radioactive wastes that retain their toxicity for thousands of years, greenhouse gases that remain trapped in the atmosphere for generations, the channels carved through the ocean by continuous dredging, the buildings, bases, pipelines etc.) exacerbate the possibility for disastrous emergences and monstrous hybrids. Long-forgotten deposits of radioactive wastes could leak into ecosystems without warning, the gases trapped in the atmosphere could force abrupt changes in the climate system. Thus, the more that the past accumulates (through processes of inheritance and cultural transmission such as media, but also through objects and materials), the more potential there is for non-linear transitions or tipping points.

The consequences of bringing oil and its residues into combination with icy environments are potentially catastrophic. If a major oil spill were to occur, it would likely remain trapped in the ice, ice serving as a kind of archive. In 1942 a US Navy boat ran aground during a storm, with the captain forced to eject the vessel’s bunker fuel in order to save the ship. The ejected bunker oil devastated the ecosystems of local barrier islands. Fifty years later, a similar storm that hit the ship returned and the waves washed up where the bunker fuel was deposited devastating the same inlet yet again. Oil buried in ice retains its toxicity for decades, and can return and hit the environment again and again across long periods of time (Anderson 2009: 220-221). This archiving can increase future uncertainty. Temporal complexification designates is whereby, like oil trapped in ice, the past does not ‘go away’ but continues to inhere in the present. The NSR is in many ways a forgotten by-product of inter-imperial rivalry repurposed as a 21st century transnational trade route. Yet 20th century geopolitical legacies live on and colour present-day dynamics, with many referring to ongoing tensions and hostilities as a 'Cold War 2.0'. Paths and pasts linger, even when the conditions that gave rise to them are no longer present. These pasts are embodied in the abandoned military infrastructure that the Soviet Union constructed along its Arctic coast in the 20th century. The mere existence of these bases is a source of volatility; even if the political situation has changed and relations between Russia and the West are more cordial, an incident can push this fragile post-Cold War settlement into reversal and reactivate the dormant potentials literally embodied in Cold War Arctic bases.

Adam and Groves argue that: 'Socially produced change, innovation and progress mean that prediction of social futures by scientific means is a far more precarious affair' than 'knowing the next eclipse of the moon or that water will freeze at zero degrees centigrade (2007: 26). Yet the freezing and melting patterns of Arctic sea-ice which pose such formidable obstacles for climate modelling, demonstrate the 'liveliness' that is often taken as an exclusive feature of 'social' worlds.  Indeed, what makes modelling 'social' futures such a precarious endeavour is not so much that there is something uniquely unpredictable about human activity, but the complexity of interactions in social worlds – including the presence of unruly non-human agents within human collectives. It is not so much the 'social', but complexity which engenders turbulence which lies 'beyond the calculus of… prediction' (Cresswell, Martin 2013: 456).  'The more socially interconnected the activity', continues Adam, the more chance there is for interference and derailment of the plan' (Adam, Groves 2010: 30). The development of the Northern Sea Route depends on the creation of a range of synergies, with no central planner able to control its evolution. The heterogeneous elements of this Russian Arctic energy-extraction and cargo-mobility nexus are anchored in and sensitive to a range of resource extraction and cargo distribution activities, both geographically proximate and distant, which could hasten, impede or derail Arctic shipping networks. But these interconnections involve more than just social ‘elements’, but non-human materials and forces with their own latent capacities to surprise and derail. The possibility of emergent non-linear behaviours means that we cannot presume that geophysical processes will ‘keep behaving in essentially predictable and manageable ways’ (Johnson 2010: 843), with the possibility of increasingly frequent and severe storms, for instance (Ostreng et al 2014: 163). Emergent properties in the climate system could be triggered by the magnified radiative forcings that result from ‘accumulation by degradation’ (see chapter four).

Just as quickly as the NSR re-emerged, so it seems to be fading away. What may have been a tipping point for the NSR, may just have been a flash in the pan, random noise eagerly consumed by a media environment obsessed with mapping emerging trends, or domesticating the future in the form of ‘the next big thing’. Tipping points however only become evident as tipping points retrospectively, or after the event. Yet it would be unwise to write-off the NSR, or related Arctic energy extraction activities, especially given the long-term trends in sea-ice decline, and long-term patterns of resource exploitations. Architects and promoters are hopeful, pinning their hopes on the inevitability of eventual full-scale Arctic hydrocarbon exploration:

> We have hydrcocarbon resources or even reserves in the Arctic, billions and billions of dollars have been invested by big oil companies and licenses. The licenses have already been sold. It’s just a matter of time before these resources are developed (interview A).

Conversely, a sense of hope also infuses Greenpeace’s logistics manager. Greenpeace seek a moratorium on drilling in the Arctic, similar to the one now in place for Antarctica. ‘You have to be hopeful’, as he put it regarding the possibilities of such a moratorium being emplaced. This chapter has demonstrated just how fragile the current Arctic conjuncture is, depending on a ‘precarious coincidence of commodity prices, international regulatory regimes, entrepreneurialism, territorial sovereignty, and fundamentally uncontrollable physical processes’ (Jonson 2010: 843). There are many northern sea routes, and there are many possible futures in the making. The ways ships, ice and oil might collide together in the future, and the consequences both for the Arctic and for the rest of the world, remains an open question.

But whilst impossible to know in advance the precise future of the NSR, an emerging expert consensus is that rather than rivalling or replacing the Suez Canal, the NSR is most likely to form a niche transportation route, for destinational shipping of resources from the Arctic to markets in Asia (Farré et al 2014). This would seem to follow a pattern whereby early expectations and promises regarding the disruptive potential of innovations, are thwarted, but then settle into more specialised – but nevertheless significant roles.

## Conclusions

What has the research demonstrated? Focusing on what many would consider an 'extreme' case study makes visible processes and dynamics that are 'more difficult to apprehend in their milder versions' (Sassen 2014: 11). The remote, semi-frozen yet constantly moving maritime Arctic, poses a unique and particularly difficult operating environment for large-scale sociotechnical systems, one that fractures, interferes with or 'scrambles' nearly all aspects of operation, including technologies, politics, economics and regulatory frameworks. The ice that defines the Arctic exerts an especially palpable gravity, in as far as it so often 'slows down, frustrates and even prevents human activities and encounters' (Dodds, Nuttall 2015: 62).

Firstly, therefore, the research demonstrates the enmeshing of global social, economic and political processes with global 'earth' system processes, which thwart, facilitate and surprise people, organisations and institutions. As well as the gravity exerted by global markets, commodity prices, infrastructure, and political-economic incentives, elemental forces affect the viability, establishment, disruption and contestation of conjoined Arctic shipping and resource extraction networks. This means the purview of social scientific investigation must be expanded so as to be sensitive to the differences made by non- and more-than human entities and forces, and that social research needs to incorporate the findings of the physical sciences, so as to come to terms with these alterities.

The research has demonstrated the difficulties involved in attempting to domesticate one of the most 'remote' - or sparsely peopled - spaces on the planet, and turn a maritime region shifting increasingly unpredictably between solid and liquid states into smooth surfaces across which force can easily be exerted. Whilst the Arctic may be positioned in logistical imaginaries as a transitional space providing speedier and safer passage for Arctic resources and cargo between the mega-cities of Europe and

Asia, the preceding chapters have shown that there is no simply moving through or across the Arctic. The material specificities of Arctic space impinge on all aspects of operation, with states, shipping and carbon capitalist interests forced into negotiation, or into a dance of agency, with a particularly turbulent surrounding environment. This involves not only the hazards associated with ice, storms, fog, a moving ice-edge and mobile ice floes, but the important differences made by the vast distances from concentrations of people and expanses across which infrastructure need be emplaced, maintained and coordinated.

Examining the role played by earth forces in *impeding* human action, invites a corollary appreciation of the taken-for granted role played by elemental forces in facilitating such action, enabling us to appreciate the ways in which the (liquid) 'ocean itself becomes an essential actor in the drama of globalization' (Mentz 2015: no page). Frozen water and the obstacle it poses to shipping invites us to appreciate the role of liquid ocean space in subtending global social and economic life, its acting as the 'hidden partner' in successive 'waves' of globalisation (Sekula 1994), from the 'long 16th century' European maritime expansions and colonialism, through to today's container shipping, global production networks and China-led globalisation.

The research highlights the central role of shipping, logistics and ocean-space in environmental change processes. The relatively obscure (to social scientists) practices of shipping and logistics play a central role in the establishment and maintenance of high-carbon systems and lifestyles, involving the dense agglomeration of people in mega-cities, and astounding material recombination and complexification. Changes in the very materiality of the ocean are facilitating further globalisation processes. Parts of the Arctic maritime are becoming more integrated into global production circuits, with the Arctic an increasingly significant 'operational landscape', woven into and caught up with processes of planetary urbanisation (Brenner 2016). Yet this research has attempted to redress the land-bias implicit in terms such as Brenner's 'operational *land*scape', showing the ways in which shipping lanes, ports and maritime infrastructure are central components – and not simply part of the 'backstage' – of urbanising processes.

The research therefore bridges the gap between sociology and geography practicing what we might call 'geo-sociological' analysis, which recognises and examines the embedding of social and economic processes in particular geographies – albeit often mobile and shifting geographies or circuits. Geo-sociological analyses, further spatialises the social sciences, whilst also requiring geologic thinking, expanding the temporal horizons of social scientific investigation, emphasising the gravity exerted over social life by largely imperceptible processes occurring over very long or 'inhuman' time periods. Furthermore, 'geo-sociology' stresses that all 'social and political formations are implicated with specific geological formations' (Clark 2016: no page), with (immensely concentrated) flows of energy representing geological subsidies (chapter four) to the present day, 'a transfer of geological space and time that has underpinned the compression of time and space in modernity' (Clark 2016: no page). The next sections discuss the contributions of the thesis to research on climate change, the Anthropocene, and Arctic amplification processes, as well discusses the opportunities and problems that may result from researching the Arctic and other geopolitically sensitive areas.

Heating processes, the research has shown, provide opportunities, or affordances, as well as disasters underway and in-the-making. Creation and destruction are confusingly entwined in the contemporary Arctic. On the one hand, increasingly accessible Arctic waters are a consequence of global heating processes, and thus part of a 'slow motion disaster'. On the other hand, the fuel savings made possible by the emergence of a shorter Arctic shipping route is often figured as an ‘unexpected benefit’ of global warming, potentially even enabling reductions in carbon emissions. Climate change processes involve not so much destruction, as what Beck calls ‘metamorphosis’, altering societies ‘in fundamental ways, entailing new forms of power, inequality and insecurity, as well as new forms of cooperation… across borders’ (Beck 2016: 37-38).

The research has shown the profoundly *uneven* character of change processes. This unevenness is manifest both in the varying ways in which people and places are affected by temperature rises, as well as in the increased inter-annual variability of the melting process (see chapter seven). The opportunities and risks presented by Arctic heating processes, are unevenly distributed such that enhanced mobility for extraction and shipping, presupposes the circumscription of others’ mobility or zone of operation, as the hunting season is cut short and seasonal migration patterns are disrupted (on the circumscription of mobility of Greenlandic hunters due to melting ice see Hastrup 2016). Yet the research has also shown that whatever ‘opportunities’ presented by change processes are highly precarious.

Focus on icy worlds draws our attention to the potentially *abrupt* character of change processes. Transitions in the overall earth system can be surprisingly abrupt – ‘with climate and other entangled subsystems shifting their entire operating state in timescales briefer than a human lifetime’ (Clark 2016: no page). The transition from solid ice to liquid water involves the sudden crossing of a threshold, and ice is key to abrupt change. Ice – as immobilised water - locks water out of the hydrological cycle for long periods of time, and large-scale melting threatens to release a vast amount of water back into the water cycle - very quickly (Ball 2000: chapter three). Ice sheets are shedding meltwater and icebergs at an accelerating rate. Greenland, for instance, is now experiencing an average net loss of about 303 billion tons of ice every year. the sea will rise between a half meter (1.6 feet) and a full meter (3.2 feet) by the end of the century (IPCC 2014: 1384), although research led by James Hansen concluded that sea-level changes driven by ice-sheet collapses could well exceed six feet within 50 to 150 years (Hansen et al 2015).

And as the ice melts, the materials it kept out of circulation are liable to re-enter. If permafrost melt continues, gigatons of carbon could be released into the atmosphere, further warming the planet. In 2016 in the Yamal-Nenets region of Siberia, a 'zombie' disease, anthrax, long preserved in a frozen reindeer carcass, was released after a buried deer carcass thawed, releasing spores of bacteria that had been 'locked away' since the early 1900s, the time of the last major outbreak. The outbreak lead to calls by the region's governor, home to 40,000 indigenous inhabitants reliant on reindeer herding, for a cull putting further pressure on traditional livelihoods, already stressed by diminished reindeer numbers (Luhn 2016). The cull has been opposed by many Nenets, on the grounds that it is motivated by the interests of the extractive industries, which currently share the area with the herdsman (Luhn 2016). This shows the complex, non-linear ways through which climate change processes are becoming entangled with extant social and political contestation processes.

Northern sea routes are other such entities, like anthrax re-animated with changes in the state of water; these routes ultimately make possible and help to generate the further unearthing, distributing and burning of carbon, and might be seen as part of a temporally and spatially more expansive 'slow-motion' disaster. Although Arctic governance narratives typically assert or assume that extraction and conservation can exist harmoniously (Gritsenko 2016), the contradictions between exploitation and conservation are now at their starkest (Bonneuil, Fressoz 2016: 23-24). In order for global temperatures to stay within the 2 degrees' C threshold decided on by representatives of 195 nation-states at the 2015 Paris agreement, 80 per cent of known reserves of fossil hydrocarbons must remain in the ground.

The loss of Arctic sea-ice is one of the most significant events in human history, with consequences that will reverberate throughout future generations. Yet compared to the ‘seismic’ political events that 2016 has witnessed (Brexit in the UK and the election of Donald Trump in the US) and which have captured the attention of the media and commentariat, the on-going decline of sea-ice has produced only modest-sized waves in the media. Relations between humans and subtending ‘natural’ processes, are thus in urgent need of further social research.

The Arctic is an ‘Anthropocene space’, from the radioactive wastes under it, to the Arctic haze in the air, to the melting sea-ice. It is therefore a real-world laboratory attracting increasing social scientific attention. Further research on the Arctic, or the ways in which the Arctic and the rest of the world are linked, need not necessarily entail travel to it, although undoubtedly such experiences augment desk research. Furthermore, dealing with (geo)politically sensitive situations and subjects requires ensuring especial diligence, with regard the identification of key actors, the organisations of interviews, and the handling of sensitive data. Such research may require additional time and planning to successfully negotiate with the relevant organisations and institutions, and one must be cognizant of the ways in which things like conditional access, can shape the research process (see chapter two).

Arctic ‘amplification processes’, I hope to have shown, must be made to include anthropogenic activities or ‘social’ processes. Accounting for how ‘human’ actors such as businesses, states and individuals react to and mediate change processes, facilitating, impeding or otherwise shaping the dynamics of Arctic amplification processes, is no small undertaking, made more complicated by the fact that actors not only react to environmental change, but are also engaged in 'anticipating, waiting, hoping, pondering, and imagining' it in advance of its arrival (Hastrup 2016:4). Understanding this anticipatory orientation, where 'the future is implicated in any act' (4), is key to understanding the specificities and the differences made by human actors – albeit in concert with technical agents and imaginative resources, comprising models, records, retentions, habits and expectations, which intervene and mediate between people and environmental change, such that the latter rarely simply respond to discerned environmental shifts, but seek to act in advance of them. The research has made initial steps in mapping in more granular fashion the intersections between environmental change processes and anthropogenic systems in the High North.

**Anthropocene mobilities**

The transformations associated with the 'Anthropocene' have ominous consequences for the practices and forms of sociotechnical life that might be called civilization, comprising urban concentration, functional differentiation and divisions of labour, global networks of travel and trade, population growth and raised standards of living for many. The very 'success' of the human species has led to the undercutting of its own conditions for survival. Yet, when viewed over long periods of time, changes currently taking place are part of the on-going, perfectly 'natural', metamorphoses of the Earth system, which has undergone dramatic upheavals in its past.

The Earth is a complex system made up of subsystems that are traversed by continual matter-energy flows, in immense circuits or feedback loops. The circulation of objects, resources and materials by anthropogenic mechanisms has come to rival - in terms of mass moved over distances – the Earth's own major transport mechanisms - rivers, oceans currents and jet streams (Haff 2010). Indeed, the infrastructures that straddle the planet's land, sea and air spaces are merely the latest manifestation of what Szerszynski (2016) calls 'planetary mobilities'.

Sagan argues that 'our' effects on the atmosphere is 'orders of magnitude less impressive than that of previous life-forms' (2016: no page). The changes resulting from the growth and pollution of cyanobacteria, around 2.3 billion years ago, had calamitous consequences for much life on the planet at the time, but was a 'key condition for the possibility of our [human] existence and evolution' (Sagan 2016: no page). And, while previous organisms have never created global communications and shipping networks, 'we are hardly the first species whose populations have moved from being solitary individuals to increasingly connected forms' (Sagan 2016: no page). Globalization and atmospheric transformation are part of the Earth's 'natural' history. Thus it would appear that for all the momentous change associated with present, there is a kind of cycling-back to previous phases in the Earth's history. Change processes may best be understood not in terms of linear trajectories, but as loops, where one is, like the looping voyages of container ships or circumpolar sea routes, 'always simultaneously facing the point of departure *and* arrival' (Bissell 2013: 358).

The ways the Arctic is linked via circuits and traffic of all sorts – heat, air, water, ships, pollutants, capital, marine organisms, resources, people – calls into question customary understandings regarding the 'the Arctic's' 'location', as global loops conjoin spaces in ways that go beyond the logic of territorial proximity or spatial contiguity.

The research has demonstrated the ways in which routes are carved through successive journeys, and follow those that came before. Times are thus layered and leaky, creating temporal 'smudges' which undo existing distinctions and divisions between 'eras', as well as between pasts, presents and futures. For instance, there is no reason why the ‘long sixteenth century’ should be shut-away, consigned to the past, and thought of as different to the ‘contemporary world’ of cargo shipping. Global social analysis should be conducted within what Braudel (1994) conceived of as the ‘longue durée’. The owner of a Lancashire mill in the 1800s who replaced his water-mill with coal-powered machinery could have had no idea that this would affect Arctic sea-ice in the 21st century (Malm 2015: 1), breathing new life into age-old efforts to find a quicker route to the Far East, although the same cannot quite be said of today’s urban dwellers who drive gas guzzlers, who do so with at least some knowledge of the consequences of their actions.

Indeed, recent research has demonstrated that with each tonne of $CO_2$ that a person emits anywhere on this planet, three square metres of Arctic summer sea ice disappears (Notz, Stroeve 2016). In the UK, the average emissions are 7.5 tonnes per year, meaning 22.5 square meters of ice loss, according to the authors of the study. Thus, despite the lags and latencies in between emissions and their ‘downstream’ consequences, it is now possible to estimate with some degree of precision the amount my action contributes to ice-loss. Yet from a geo-*sociological* point of view, attributing agency to individual human actors in this way misses the ways in which the latter are enmeshed in systems or assemblages which shape, constrain and pattern their action (i.e. car-use may be presupposed by the geography one inhabits), with ‘individuals’, like molecules in a wave, subject to intersecting political, economic and technical forces. The ways in which a sense of agency might be retained and indeed nurtured under conditions where ‘individuals’ (of various kinds) find themselves increasingly subject to forces beyond their control, is a matter of paramount urgency for contemporary social scientists. How might we carve out a sense of agency?

The research also demonstrates the vastly expanded spatial and temporal scales at which anthropogenic activity now occurs. Such expansionism is starkly embodied in the emergence of semi-routine cargo shipping and resource extraction in the Arctic. Human collectives, encompassing not only people but objects, infrastructures and wastes, have come to fill-out space and time, reaching remote corners of the planet, far above and deep below its surfaces, reaching-back into the past by tapping stores of ancient sunlight, and producing by-products that cast shadows over distant futures. This ‘filling-out’ is also a ‘filling-in’, with anthropogenic materials infiltrating the most intimate recesses of organisms involving microscopic and atomic mobilities, processes and exchanges, albeit with geologic consequences. Yet this radical expansion of the shadows that human collectives cast over the world, has left our collectives in a much more precarious position.

Our ‘deep elemental underpinning’ writes Clark ‘is at once a source of profound insecurity’ (2011: xiv). Vulnerability to turbulent weather and climate events is shaped and exacerbated by the ways in which societies have come to be organised. Two thirds of the world’s largest cities are in coastal or low lying areas. The ability to harness the seas and canals for trade and resource extraction, has led to the thriving of coastal cities, but this very sustaining proximity to the oceans (as well as rivers and canals), is now a major source of vulnerability. Plummeting Arctic sea ice cover is linked to extreme weather events such as storms and floods in Europe and severe cold in the US (Francis, Skific 2015). As the Arctic warms faster it is thought, the difference in temperature between the mid-latitudes and the Arctic region decreases, which consequently affects storm tracks and the location and strength of the jet stream (Francis, Skific 2015). Future work could therefore examine the Arctic in relation to other places, considering in more detail the climate connections – routes and loops that link the Arctic to (for instance) the UK.  The floods – and their cascading consequences that hit the UK in 2015/16 showed how ‘water can be harnessed, but not tamed. We can make it serve us in little ways; its capacity to dominate and overcome us is far greater' (Ball 2000: 54). If the future is to be marked by interruption, intermittency and environmental extremes, then one could well look to the Arctic for examples as to how people have – with varying degrees of success, navigated such turbulent environments.

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