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"The ice edge is lost...Nature moved it": Mapping ice as state practice in the Canadian and Norwegian North

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Abstract

This paper explores how 'ice' is woven into the spaces and practices of the state in Norway and Canada and, specifically, how representations of the sea ice edge become political agents in that process. We focus in particular on how these states have used science to 'map' sea ice – both graphically and legally – over the past decades. This culminated with two maps produced in 2015, a Norwegian map that moved the Arctic sea ice edge 70 km northward and a Canadian map that moved it 200 km southward. Using the maps and their genealogies to explore how designations of sea ice are entangled with political objectives (oil drilling in Norway, sovereignty claims in Canada), we place the maps within the more general tendency of states to assign fixed categories to portions of the earth's surface and define distinct lines between them. We propose that the production of static ontologies through cartographic representations becomes particularly problematic in an icy environment of extraordinary temporal and spatial dynamism, where complex ocean-atmospheric processes and their biogeographic impacts are reduced to lines on a map.

Introduction

"We are not moving the ice edge. It is actually nature that is currently moving the ice edge."

-- Erna Solberg, Prime Minister of Norway (Solberg 2015)[1]

"Presto! More ice, just in time for an election. Gosh, even Mother Nature has been cowed into co-operating with [Canadian Prime Minister Stephen] Harper's ambitions."

– 'Rogue Chimp', online comment (Semeniuk 2015)

On 20 January 2015, the Government of Norway released a new map of its northern waters (Figure 1). The map quickly became a topic of national debate because it moved the location of the southern edge of sea ice northward by some 70 km, in comparison with an equivalent map that was issued in a report that had been commissioned by the Government of Norway in 2003. The new map had significant implications for Norway's all-important offshore oil and gas industry because Norway's Lofoten-Barents Sea Management Plan prohibits oil exploration in a number of environmentally sensitive zones, including 'areas along the edge of the marginal ice zone and the polar front' (Ministry of the Environment 2011, 138). Following the release of the new map, critics and supporters of petrochemical development alike were quick to note that, with the ice edge's northward shift, the entire Southeast Barents Sea Offshore Oil Province was now open for development. Indeed, environmentalists suspected that it was hardly a coincidence that the new map was released on the same day that Norway opened new Barents Sea exploration blocks for competitive bidding. Lars Haltbrekken, Chairman of Friends of the Earth Norway, charged that the new map was part of a relentless oil politics in the Barents Sea, where 'anything is done to please an industry belonging to the past' (Norwegian News Agency 2015a), a position echoed by marine biologists and oceanographers (Norwegian

News Agency 2015b; Sundby 2015) as well as opposition politicians (Andersen 2015, Bjørndal 2016). It was in response to such assertions that Prime Minister Solberg made the statement quoted at the beginning of this article, defending the policy change as a mandate from 'nature'.

Insert figure 1 about here

Just three months after the release of the Norwegian map, the Government of Canada published a revised version of its *Atlas of Canada.* The atlas' national map of Canada (Figure 2) also depicted the edge of sea ice. However, in contrast with the Norwegian map, the Canadian map moved the ice edge about 200km *southward* in comparison with the previous national atlas, which had been published in 2006 (Figure 3). The redrawing to indicate *more* ice is counterintuitive, given that between 1979 and 2012 Arctic sea ice extent decreased at a rate of 3.5 to 4.1% per decade (.45 to .51 million km^2 per decade) (Intergovernmental Panel on Climate Change 2013, 319). The politics behind the new Canadian map are not entirely clear. Some, including geographer Robert McLeman, speculated that the depiction on the 2015 map was an act of cartographic 'fakery' that reflected Prime Minister Harper's scepticism about climate change (Kwong 2015), an opinion that echoed popular reactions to the map illustrated by the online comment by 'Rogue Chimp' at the beginning of this article. Others, including Canadian Ice Service forecaster Denis Dubé, countered that the shift was due to a well-intentioned change in methodology that, in addition to following 'international standards', would facilitate future awareness of sea ice reduction by better displaying its variability (Kwong 2015). Still others

took a middle ground, asserting that although the new map likely was not of devious intent its production (and subsequent consumption) could not be separated from a broader political context. Illustrative here is an online comment on the Canadian Broadcasting Corporation's story on the new map, in which 'Rickinedmonton' acknowledged that although the map was not 'some kind of right wing denialist conspiracy…some [climate change] deniers are prone to make disingenuous use of it' (online comment in Kwong 2015).

Insert figure 2 about here

Insert figure 3 about here

As is discussed below, much of the reason for the differences in the Norwegian and Canadian depictions of the sea ice edge, and the changes within each country's depictions, stems from their use of different methodologies for defining and depicting the limits of sea ice. Not only did Norway and Canada use different definitions of 'sea ice' and different ways of aggregating the data to obtain identifiable, static 'edges' (limits), but the two countries each adjusted their methodologies over the time period in question. And of course the maps themselves are entirely different products, designed for different purposes: While the Norwegian map is a fairly technical object, designed to facilitate state planning, the Canadian map was developed for popular consumption, to impart a sense of the nation to Canadian and non-Canadian viewers.

Thus, our aim here is not to compare the two maps or to highlight their different political or geophysical orientations and presumptions. In all their differences, they defy comparability. Rather, we are intrigued by their underlying

similarity. The two maps share a common concern with knowing and showing space by dividing it, in particular through the drawing of a singular boundary known as the 'ice edge', which in turn imparts a specific, Western politics of space. In our 'nomospheric' world (Delaney 2010), where spatial divisions support legal categorisations and legal systems support spatial ordering, boundary lines like the ice edge are ripe with political meaning, becoming not just *boundaries* but *boundary objects*, concepts that frame social understanding of the world (Star and Griesemer 1989) and that therefore set out ideas about possible futures. Thus, although we focus on the two 2015 maps and their antecedents, our objective is to move beyond them. Through a sustained examination of these two maps – their history, their reception, and their grounding in complex webs of state interests and presumptions about underlying geophysical and biogeographical processes – we seek to explore the challenges inherent when an ontology of fixed spaces is applied to an environment characterised by an exceptional level of spatio-temporal dynamism and material complexity and how efforts to address these challenges reflect and reproduce institutions of social power.

Defining water, defining ice

In our effort to understand the ice edge as a discursive construct with material effects, we turn to materialist theories of politics, in which contests over space are understood as occurring amidst the dynamic composition, decomposition, and agency of material nature (e.g. J. Bennett 2010; Coole & Frost 2010; Dittmer 2014) and which suggest that designations of fixed categories of space must be contested. To turn to a few examples, the island, which seemingly can be

understood unproblematically as a body of land surrounded by water, has been found to defy definition, as island lifeways, ecologies, and political systems exceed the island's borders (Mountz 2015; Royle 2001). Air similarly evades unitary definitions, as it is simultaneously medium, element, and atmosphere (Adey 2014). Ocean scholars note how the boundaries of the ocean exceed the limits of the shoreline (Spence 2014), and that the shoreline, which is purported to divide the planet's surface into essential categories of land and sea, itself is typically a series of points of exchange rather than a boundary between two distinct spaces (Carter 1999). Furthermore, these points that unite as well as divide are themselves in constant motion due to changes in the volume of water and the displacement of land (Steinberg 2013).

Sea ice is a similarly contested concept. At one level, it is clear what sea ice is: water of marine or oceanic origin that, because of temperature and pressure conditions, is encountered on the surface as solid. But this definition is complicated by numerous factors. The formal category 'sea' is itself defined by arbitrary boundaries: What is the threshold level of salinity (e.g. where does one draw the boundary between salt water and fresh water, and how does one classify liminal spaces such as estuaries and salt marshes)? Beyond salinity, what other properties, such as turbidity or the presence of marine microorganisms, are necessary to designate water as 'sea water'? To what extent does sea water need to be permanently distinct from underlying soil to be defined as 'sea' (e.g. how does one classify intertidal zones or tidal pools)?

Even if one can delimit the sea as a spatial unit, the designation of sea *ice* raises new questions. Sea ice comes in many forms, as sea ice glossaries produced by scientific institutions attest (e.g. Linder 2003; Canadian Ice Service

2016), and even these typologies ignore the rich knowledge of sea ice forms and processes held by Inuit and other indigenous northern peoples (e.g. Aporta 2011; Carey *et al.* 2016; Inuit Circumpolar Council 2008; Krupnik *et al.* 2010). Defining sea ice is further complicated by methodological difficulties. Water that is essentially solid frequently has puddles of liquid on its surface, complicating efforts to use satellites to remotely sense the presence of ice from albedo reflectivity (Breivik *et al*. 2010; Howell *et al.* 2005).

In addition, because sea ice occurs in various combinations with liquid sea water, fresh water, land, air, and other objects, even if one can define sea ice as a singular object it is not necessarily possible to define a *zone* of sea ice, let alone a distinct sea ice *edge*. And even if one is able to define a linear sea ice edge, mapping it poses challenges because it is rarely (if ever) static, moving with wind and ocean currents from hourly to seasonal time-scales, in addition to longer-term trends in average seasonal positions associated with climate change. And finally, sea ice, even when formally defined, serves a range of functional properties. The same area of sea ice may be a hazard to a ship, a highway for a dog sled or snowmobile, and a place of refuge for a polar bear. Sea ice may simultaneously be a barrier to movement, a surface across which movement is facilitated, and an element, that, in its lateral drift, *is* movement (Peters 2015).

Thus, the sea ice that is 'mapped' in one place may be significantly different – in form, function, permanence, and even in its elemental 'iciness' – from that mapped somewhere else. As Steinberg and Peters (2015, 260) note, 'The phenomenology of sea ice, as a particularly dynamic form of water, simultaneously destabilises conventional understandings of both geopolitics (as areal) and geophysics (as static), contributing to an ontological confusion that

underpins much of the ongoing debate over the Arctic's future'. In its attempt to add stability and definition to a dynamic and indeterminate environment, the mapping of sea ice attempts to resolve this 'ontological confusion' through an alignment of law, cartography, and science.

Defining ice zones and ice edges

Although the concept of sea ice (or ice-covered ocean) occurs with some frequency in local law and state regulations, as well as making a brief appearance in the United Nations Convention on the Law of the Sea (UNCLOS) (Baker and Mooney 2012), there is no universally accepted standard for designating zones of sea ice. Some geoscientists use data based on observation of *sea ice area* (the number of pixels within an area of ocean with albedo reflectivity indicating frozen water) to make determinations about sea ice presence in a large area of ocean. However, the more commonly used statistic is *sea ice extent*, where data is aggregated to the level of the *cell*. The website of the US National Snow and Ice Data Center (NSIDC) helpfully likens the two measures to alternate ways of measuring a slice of Swiss cheese: "Extent would be a measure of the edges of the slice of cheese and all of the space inside it. Area would be the measure of where there is cheese only, not including the holes" (National Snow and Ice Data Center n.d.(b)).

When measuring ice extent, cell size is conventionally set at 25 km^2, so if one is using data from a satellite with 1m^2 resolution there would be 625 pixels in a cell. A cell is then said to have ice extent if the percentage of pixels in the cell indicating ice (the ice concentration) exceeds a certain threshold. In this example, if one is using a 15% threshold then so long as at least 94 of the pixels in the cell

indicate ice the cell is declared to be an area of ice extent. If fewer than 94 indicate ice (i.e. if the ice concentration is less than 15%) the cell is designated open water (Kvingedal 2005; National Snow and Ice Data Center n.d.(a)).

While this seems straightforward, there is no evident basis, other than convention, for choosing a 25m^2 cell as the standard unit of aggregation. Additionally, designations of ice extent are likely to change as improved satellite resolution increases the number of pixels in a cell. Perhaps most importantly, there is no standard for defining the ice concentration threshold used to distinguish 'sea ice extent' from 'open water'. The Canadian Ice Service sets the threshold at 10%, the NSIDC (whose data is generally used in Norwegian maps) sets it at 15%, and others, as the NSIDC (n.d.(b)) notes, set the threshold as high as 30%.

Variance in data resolution and definition of the sea ice extent threshold are matched by variance in time scale. Turning just to the three maps presented above, the 2003 Norwegian ice edge line (the green line on Figure 1) was based on data from a 23-year data-set, going back to 1967, when data first became available. Using this data, the map identified ice-covered areas as those where there was at least a 30% chance of ice occurring in April (the month identified in the report as having maximum ice extent), using the 15% NSIDC threshold. The 2015 Norwegian line (the blue line on Figure 1) used an identical standard, except that the 23-year data-set was expanded to 30 years to align with the norm in climatological research. The 2006 Canadian map (Figure 3) indicated the ice edge at the 'approximate limit of polar ice'. Subsequent discussion surrounding the 2015 map revealed that this referred to the September minimum but left it unclear whether data was derived from just the most recent year of observation,

the northernmost limit ever observed over an unspecified time-period, or a median of annual minimums observed over that unspecified time-period. The 2015 Canadian map (Figure 2) clarifies that the limit is the minimum (September) extent, defining this as the median point over a 30-year data set of September observations.

As critical geographic research on the Arctic has demonstrated, the shifting nature of Arctic sea ice, its liminal properties, and ambiguity in the divide between sea ice and open water have complicated both Arctic politics (Gerhardt *et al*. 2010; Strandsbjerg 2012) and the translation of Arctic science into policy and planning narratives (Kristoffersen 2014; Veland and Lynch 2016; Worms and Sörlin in press). Additionally, the failure of many to appreciate the connection between these binary narratives of Arctic ice and the complexities underlying Arctic livelihoods and scientific practices reflects the epistemological narrowness of much research on glaciers and sea ice (Carey *et al.* 2016). In this article, we build on these works, analysing the history of the Norwegian and Canadian ice edge mapping projects to extend insights on the role of maps, ice, and science as political actors that, through ordering space, order the world.

Mapping a chaotic world

Central to the story of ice edge mapping is, of course, the map. Almost thirty years after Brian Harley's (1989) foundational work in critical cartography, one hardly needs to stress that a map is a partial depiction that, through simplification and erasures, performs political 'work'. This perspective, however, has itself been critiqued by those who stress that a map's power lies less in its existence as a (misleading) representational object and more in its power as a

more-than-representational actant that, through *purporting* to represent the world as a static, legible object, joins with other elements to shape that world. As networked relations emerge between the map, the reader, and the cartographer, new spaces and subjectivities are produced as individuals use the map to locate themselves in space (Conley 1996; Del Casino and Hanna 2006; Kitchin and Dodge 2007). At the same time, map users reproduce the authority of the map (and the authority of the institutions that produce the map) as well as the dominant statist and static 'cartographic reason' that conceptualises a world divided by visible and seemingly objective determinant lines (Pickles 2004).

In this article, we focus less on the map as a force that constructs subjectivities and more on the map as an object that serves simultaneously as a tool for communicating power (through reference to implicit understandings of space) and an arena for contesting power. In part, this focus is mandated by a lack of ethnographic data on individuals encountering state-produced ice-edge maps. However it also is a choice taken in light of the rich genealogical history that accompanies a state-produced map: a history of legal reasoning, surveying, enabling legislation, and policy debates behind the map and the public discourses and practices that surround its reception. In addition, the role of the map in producing and communicating state knowledge of space is particularly prominent in the Arctic, in part because it is a region that many individuals (including some who have the power to shape the region) experience *only* through maps and other mediated forms of knowledge and in part because the actual environment there differs so significantly from these state officials' personal experiences (Medby 2016; Steinberg *et al.* 2015; Strandsbjerg 2012).

Every state map works in tandem with a spatio-regulatory framework. For Arctic sea ice, a notable expression of this framework can be found in Article 234 of the United Nations Convention on the Law of the Sea (UNCLOS). The only article in UNCLOS that acknowledges that sea water may have a frozen state. Article 234 states, in its entirety:

> Coastal States have the right to adopt and enforce non-discriminatory laws and regulations for the prevention, reduction and control of marine pollution from vessels in ice-covered areas within the limits of the exclusive economic zone, where particularly severe climatic conditions and the presence of ice covering such areas for most of the year create obstructions or exceptional hazards to navigation, and pollution of the marine environment could cause major harm to or irreversible disturbance of the ecological balance. Such laws and regulations shall have due regard to navigation and the protection and preservation of the marine environment based on the best available scientific evidence. (United Nations 1982)

As Claudio Aporta (2011) has noted, Article 234 presents a one-dimensional view of sea ice, informed by Western maritime interests that perceive frozen water solely as a hazard to navigation. For indigenous people in regions characterised by sea ice, frozen water is not just an efficient transportation surface. It is also a living space that hosts everyday activities that span areas of land, sea, and inland water as well as sea ice. As a component of this wider assemblage of surfaces, sea ice is essential for preserving well-being, and sea ice processes and ecologies are incorporated into notions and practices of community, citizenship, and sovereignty (Bravo 2010; Hastrup 2016; Inuit

Circumpolar Council 2008; Kuptana 2013). For indigenous coastal peoples of the North, the primary concern is often not the presence of sea ice but its absence, and this leads to an entirely different perspective on remotely sensed ice imagery (Laidler *et al.* 2011). For instance, an Inuit hunter might set the ice extent threshold at 85% rather than 15%, reflecting a concern with *ice-melt* as a hazard.

In addition to its singular focus on shipping, Article 234 is notable for its failure to define 'ice-covered areas', except tautologically as areas with 'the presence of ice'. Much as the focus on commercial navigation forecloses perspectives on ice that might lead to different thresholds for determining ice extent, the binary category 'presence of ice' (in UNCLOS), or 'ice extent' (in scientific classificatory schemes), is insufficient for capturing the ways in which ice and the ice edge shift in time and space.

In short, the binary division between 'ice-covered areas' and 'open water' is neither geophysically tenable nor operationally practical. Nor does it have any definitive legal clarity (Veland and Lynch 2016; see also, Baker and Mooney 2012). Yet it has gone on to inform a range of regulatory structures, laws, political talking points, and national ideologies (as well as maps) across the polar North.

Summing up these points, it appears to us that sea ice is a legal category constructed not so much by the freezing of sea water as by the mapping process that inscribes spaces (through visual and textual narratives) into fixed categories that obscure underlying ambiguities, transformations, and political agendas. The sea ice map is thus, after Latour (2007), a *seemingly* immutable (but actually quite mutable) mobile that purports to make sense out of a complex world by

assigning things to spatial categories and by carrying that knowledge into different contexts where it then can be reassembled and applied. Methodologically, this suggests that much can be learned from following the map, tracing its mutations as it is conceived, interpreted, and applied in specific contexts (the court room, the planning document, the atlas) to achieve spatial order among a community of users (Kitchin *et al.* 2013; Sparke 1998). By genealogically following the map, we explore not just its (mis)representations but also how cartographic reason is applied to construct spatial order. In the remainder of this article, we apply this approach to Norwegian and Canadian efforts at sea ice mapping, tracing the ways in which they have constructed the geo-legal category known as the 'ice edge'.

Mapping ice borders in Norway and Canada

Norway

The story of Norwegian ice edge mapping began with a 2001 civil disobedience action at Røst in the Lofoten Islands, where the oil industry had identified Norway's most 'prospective' hydrocarbon deposit (KonKraft 2009) and where Norway's partially state owned oil company Hydro (now merged with 2/3 governmentally controlled Statoil) was preparing to engage in exploratory drilling. In response to opposition from local residents and environmentalists, and in anticipation of an election that was to occur in two months, the governing Labour Party withdrew Hydro's discharge permit. A few months later, the new centre-right government stopped all petroleum activities in Arctic waters (except the only gas field in the Norwegian Arctic, 'Snow White') and asked research institutions and governmental directorates to provide assessment

reports on year-round off-shore petroleum activities in the North, with a specific mandate to produce maps that could be used to inform subsequent management plans. The principal report produced was *The Identification of Particularly Valuable Areas in Lofoten – Barents Sea* (Olsen and von Quillfeldt 2003)[2], which went on to inform the *Integrated Management of the Marine Environment of the Barents Sea and the Sea Areas off the Lofoten Islands* (Ministry of the Environment 2006, revised in 2011) that was submitted to the Norwegian government and adopted by Parliament.

Insert figure 4 about here

While there is both a cartographic and policy continuity between the map in the original 2003 report (Figure 4), the maps in the 2006 and 2011 management plans, and the 2015 map discussed at the beginning of this article (Figure 1), the map underwent a series of iterations that, we suggest, speaks to the ways in which Norwegian oil extraction policy has been advanced concomitantly with the reduction of sea ice to a static, binary, and cartographically comprehensible object. Importantly, although the ice edge is noted on the map, the accompanying report indicates that its significance emerges not because it is the southernmost point where water is frozen (i.e. the point at which ice extent meets open water) but because it is indicative of the location of the polar front. A close read of the text reveals that it is the polar front, the boundary between the cold polar air masses and the warmer mid-latitude air masses that is often broadly associated with the zone where warm southern water meets cold Arctic water, that is the zone of vulnerability: 'The polar front

is the most important oceanographic phenomenon that creates enhanced biological production…[where] organisms at all levels of the food chain are concentrated' (Olsen and von Quillfeldt 2003, 56). Furthermore, the report notes that when the warm and cold currents separate, during the spring and summer, the retreating ice creates a 'stable, but relatively shallow surface layer' which in turn leads to 'intense production within a belt of 20 to 50 kilometers' that 'follows the ice edge when it retreats northwards' (Olsen and von Quillfeldt 2003, 3).

In other words, the significance of the ice edge emerges from its association with the increased biological productivity that occurs when the intersection of water masses, resulting from different air temperatures, induces mixing that facilitates the primary production of algae. This focus is consistent with the mandate given to the report's authors, which was to evaluate areas where there were potential threats to 'biological production and biodiversity' (Olsen and von Quillfeldt 2003, 2). Significantly, the report attaches no environmental (i.e. biological) importance to the ice edge as an *object*, that is, a distinct line (or place) where ice becomes liquid. Rather, it is mapped (and subsequently emerges as a planning tool) only because it serves as an indicator of the approximate location of water temperatures associated with the polar front, which, in turn, is associated with heightened biological productivity.

As the 2003 report (and its accompanying map) evolved into the 2006 and 2011 reports (and their accompanying maps) a number of changes transpired. The text of the management plans continued to highlight the significance of the polar front. The 2006 management plan states, 'Organisms at all levels of the food chain are concentrated along the narrow polar front. As a

result, any negative environmental factors that affect the polar front may have an impact on a substantial proportion of the populations of various species' (Ministry of the Environment 2006, 33), and the 2011 management plan notes, '[The polar front] is an area for various groups of organisms; it is also a natural and dynamic biogeographical boundary, and therefore supports relatively high biodiversity' (Ministry of the Environment 2011, 26). However, the entire discussion is tempered by an acknowledgment that 'there are significant gaps in our knowledge of physical and biological processes in the marginal ice zone, the polar front and other productive areas' (Ministry of the Environment 2011, 29) and that due to this uncertainty the precautionary principle should apply when designing environmental management regulations for the marginal ice zone.

This acknowledgment of uncertainty is extended from questions concerning physical and biological processes to geographic location. Referring to the eastern part of the zone, which previously had been disputed between Norway and Russia, the 2011 management plan notes, 'The eastern part of the polar front is broader and less clearly defined than it is further west. Sea ice covers part of the previously disputed area for periods of the year' (Ministry of the Environment 2011, 26). This would seem to suggest that in the eastern region in particular it would be problematic to let the ice edge simply serve as proxy for the polar front, and this was noted explicitly in a report issued by the Ministry of Climate and Environment (the successor to the Ministry of the Environment) that accompanied the 2015 map (Figure 1): 'The sea ice's southernmost reach often coincides with the polar front, but not always' (Ministry of Climate and Environment 2015a, 24).

Amidst this recognition of uncertainty surrounding both the biological processes and the location of the polar front, sea ice – a tangible and seemingly identifiable substance – began to rise to the forefront as a spatial management tool. Whereas the initial 2003 map (Figure 4) and the text accompanying it (Olsen and von Quillfeldt 2003) highlighted the April and September ice *edges* as lines that needed to be identified for planning purposes, the map in the 2006 and 2011 management plans (Figure 5) went on to highlight the entire area between the two ice edges as an ecologically significant 'marginal ice *zone*', a change that likely was made to reflect an increasing realisation among biologists that the relationship between marginal ice and biological productivity is characterized by a series of short-term bursts in productivity caused by melting or wind-driven events rather than by a stable or even seasonally predictable ice edge associated with the polar front (see Drinkwater and Tande 2014). This replacement of the ice edge as a distinct line (or a set of two lines) with a broader marginal ice zone, and its conceptual separation from the polar front is replicated in the accompanying text: 'Both the polar front and the marginal ice zone have already been identified as particularly valuable and vulnerable areas in the management plan' (Ministry of the Environment 2011, 26).

Insert figure 5 about here

While the conceptual separation of the ice edge (or the seasonal minimum and maximum ice edges, or the zone between them) from the polar front is scientifically justifiable, the successive cartographic and textual statements that distinguished one from the other set the stage for transforming the ice edge –

formerly a proxy for the shifting site of intense ocean-atmospheric energy exchange – into a singular object that, in turn, could become a planning tool. As we have seen over the twelve years between 2003 and 2015, the 'ice edge' was transformed from the area between the April and September limits, with various probabilities of ice within that zone (Figure 4, the 2003 map), to an undifferentiated zone of 'marginal' ice cover (Figure 5, the 2006/2011 map), to a single line representing the point at which there is a 30% chance of ice extent in April using a thirty-year data set and a 15% ice extent threshold (Figure 1, the 2015 map). In the process, the 'ice edge' became a mappable line that could be joined by Prime Minister Solberg to the heft of 'nature' to justify the delineation of planning zones. As this occurred, the oceanic temperature variance and hypothesised biological productivity associated with the polar front, which was the reason why attention had been directed to the ice edge in the first place, quite literally disappeared from the map.

Although the transformation of the ice edge from a complex set of probabilities and variances to a single line could theoretically have occurred independent of the cartographic disappearance of the polar front, the two reflected a common trend toward constructing the ice edge as an ontologically distinct object that could be deployed for spatial planning purposes. Once the ice edge was established as a distinct object – i.e. once it was transformed into a *line* that separated water from ice, and resilience from vulnerability - this line could be *moved*, opening up new sites for oil exploration. In short, over twelve years, the ice edge was transformed from an indeterminate, probability-driven, and substantively insignificant indicator of underlying ocean-atmospheric forces

associated with biological productivity and environmental vulnerability into a distinct object that could be used for planning purposes.

But that is not the end of the story. Complicating the issue even further, there is yet another definition of the ice edge used by the Norwegian government. In its white paper *New Possibilities for Northern Norway: The Opening of the Southeast Barents Sea for Petroleum Extraction*, the Ministry of Petroleum and Energy (2012-2013) states, 'In areas closer than 50 kilometers to the [annual] *actual/observed ice edge*, exploration drilling in oil-bearing layers will not be allowed, in the period between December 15th and June 15th' (page 38, emphasis added). This definition contrasts with the ice edge depicted on the 2015 map, not least because it suggests that exploration drilling can take place much further north, at least in years where the ice edge happens to form at a relatively northern latitude.

As of this writing, Norwegians remain divided over how to define the ice edge. The original 2003 map, which marked the April (maximum) and September (minimum) extents (Figure 4) has largely been abandoned. Likewise, the 2015 map that defined only the southernmost (April) extent, using the criteria of 30% likelihood over a thirty-year period (Figure 1), has been formally withdrawn amidst the ongoing controversy (Sættem and Tomter 2015). Most environmentalists and scientists call for the designation of a 'marginal ice zone' or 'ice edge zone' (Aarskog 2015), following the depiction used in the maps accompanying the 2006 and 2011 management plans (Figure 5). Since the controversy surrounding the 2015 map, the various sides have strengthened their positions. The Norwegian Polar Institute, which serves as both a government directorate and research centre on polar issues, is calling for a

definition that uses the *maximum* ice extent that has occurred during the past thirty years (in contrast with the 2015 map's definition of 30% likelihood over that same time period) (Norwegian Polar Institute 2014, 8). This alternate standard, which would move the ice edge further southward, has been taken up by opposition parties in the Norwegian parliament as well as environmental activists. Meanwhile, the Ministry of Petroleum and Energy maintains its commitment to the 'actual/observed ice edge' in any given year, which would perhaps lead to the northernmost definition. Amidst all this debate, the polar front, which was closely linked to the mapping of the ice edge in the first place, has largely faded from public view, and the exploration licenses announced in 2015 with the new ice edge map (Figure 1) have been granted.

Canada

Compared to the 2015 Norwegian map, the 2015 Canadian map has had a less contested history. Certainly its reception, as well as its political import, has been much more muted. Nonetheless, the decision to change the representation of the ice edge in the Canadian national atlas is no less intriguing. As in Norway, the Canadian map points to the arbitrary (and inherently political) nature of science, as scientists, policy-makers, cartographers, and the maps that they use to communicate with each other divide nature into categories, echoing a trend that has been identified in Arctic planning more generally (Worms and Sörlin in press).

Maps have long had an important role in defining the scope – and identity – of the Canadian nation, pointing the nation northward, asserting Arctic waters as part of the national patrimony, and even implying a 'natural' extension of Canadian territory to the North Pole (M. Bennett *et al.* 2016; Steinberg 2010;

Steinberg *et al.* 2015; see also Grace 2007; Sparke 1998). This sentiment was echoed by Canada's Minister of Natural Resources in the news release that accompanied the 2015 map: 'Maps have played an important role in building our country…[and] this updated map will help Canadians better understand our evolving country' (Natural Resources Canada 2015b). It was perhaps because of this context that, for a few days after the map's release, the internet was abuzz with speculation about the reasons behind Canada's decision to replace the old indicator of the ice edge – the poorly defined 'limit of polar ice' – with the 'median [September] sea ice extent' figured over a thirty year period. In a manner reminiscent of the popular frenzy that occurred when a 2011 update of the *Times Atlas of the World* erroneously shrunk the Greenland Ice Sheet by 15% (Black 2011; Harvey 2011), the Canadian Broadcasting Corporation story reporting on the map (Kwong 2015) received 1,008 comments within days of publication, a level of attention not normally granted to something as mundane as a new edition of a national atlas.

In fact, the decision to change the depiction of the ice edge in the *Atlas of Canada* intersects with an on-going debate within the Government of Canada concerning the delineation of sea ice and its use for purposes as diverse as asserting sovereignty, guarding against environmental hazards, and promoting transportation. Article 234 of UNCLOS, discussed above, was based on Canada's 1970 Arctic Waters Pollution Prevention Act (AWPPA), which, like Article 234, holds that the heightened dangers of ice-covered waters justify heightened coastal state regulation of navigation. While there certainly are legitimate reasons for exercising exceptional regulatory measures in Arctic navigation (both because of the hazard that sea ice and ice floes pose to ships and because

of the environmental dangers associated with a potential wreck), the designation of Arctic waters as 'dangerous', and therefore requiring a heightened level of policing, aligns with Canada's desire to 'perform sovereignty' in the region (Dodds 2012).

Much of Canada's argument that Arctic waters are dangerous and therefore require heightened protection rely on their designation as 'ice-covered', which, in turn, requires a binary, static definition of ice extent (as well as the designation of an ice edge where that ice extent ends) (Steinberg *et al*. 2015). Designating these waters as 'ice-covered' and therefore 'dangerous' has the added benefit for Canada of implying that they are not suitable for reliable inter-ocean navigation, which supports Canada's argument that the Northwest Passage is not an international strait and therefore should not be subject to UNCLOS' international strait transit passage regime (Steinberg 2014). And finally, the designation of the waters of the Canadian archipelago as ice-covered supports Canada's designation of both the land *and* the (frozen) water of the Canadian archipelago as essential Canadian space, an argument frequently made by Canadian officials with reference to winter movement of Inuit Canadians across land and frozen waters (Byers 2014; Gerhardt *et al*. 2010; Vannini *et al*. 2009).

Given the political significance of sea ice in Canadian politics, the scientists of the Canadian Ice Service, the agency within Environment and Climate Change Canada that monitors sea ice, are no more insulated politically than the Norwegian cartographers whose aggregation and representation of sea ice data determine where oil exploration can be permitted. In the case of Canada, the ice extent threshold reported by the Ice Service has historically been 10%.

However, there is a history of controversy and debate concerning how the Ice Service reports ice extent, and this reflects contradictions in its mission to serve different branches of the Canadian government.

During an interview with one of the authors of this article, a Canadian Ice Service official acknowledged that although the Ice Service's primary mission is to support Transport Canada in managing the marine transportation system, the Ice Service also 'support[s] DFAIT [the Department of Foreign Affairs and International Trade, now Global Affairs Canada] in terms of their use of the Arctic Waters Pollution Prevention Act, the ice-covered waters, Article 234'. The official went on to note that in 1985, when Canada extended the area covered by the AWPPA to 200 nautical miles (so that it would be coterminous with Canada's Exclusive Economic Zone), the United States protested: 'There were 156 faxes that went out: "Are you sure that it is really ice-covered up there for most of the year," [the U.S. asked], because it is very open language'. More recently, Canada instituted NORDREG, a system of mandatory registration for ships entering Arctic waters. Again, Canada justified this heightened level of regulation because of the presence of hazardous ice, and again the U.S. protested what it saw as Canada using the presence of ice to exercise an excessive level of sovereign authority in its waters. According to the official, the Canadian Ice Service was once again called upon to verify the presence of ice, based on the 10% ice extent threshold: 'We define it as 10% [in interpreting AWPPA and Article 234] and…. now it's the same question with NORDREG. [The U.S.] keeps coming back to us asking if it's really ice-covered up there'.

At this point, a second Ice Service employee interjected to add historical perspective. In the process, he indirectly alluded to on-going tensions between

Transport Canada, DFAIT, and the Ice Service regarding the different ways that the three agencies measured and communicated ice extent:

> It's interesting because 20 years ago there was a discussion of the use of the term 'ice-covered'. The decision was that we really shouldn't use the term 'ice-covered' to describe Canadian waters, [because] that's seen as a negative….[Other possible terms were] 'ice-encumbered', 'ice-infested'. Now we are kind of retreating back to [saying] 'they are definitely "ice-covered" most of the year'. [You can] see where the pressures have changed over the years.

Left unstated was that the Inuit who actually live amidst these 'ice-covered waters' would have yet another perspective, one that emphasises that their Arctic home is constituted by connections rather than divisions between land, open water, and sea ice (Inuit Circumpolar Council 2009, Art. 1). Such a perspective would lead to different mappings projecting different politics and different understandings of space as the surfaces across which individuals move and construct their livelihoods (e.g. Pan-Inuit Trails n.d.).

Conclusion: the politics of ice

"The ice edge is lost. Those who find it, please deliver it to the address: longitude 81. Knipowitsch."

-- Nikolai Knipowitsch, oceanographer (Sörlin and Lajus 2013, 75)

"This is scientific dishonesty. Scientists need to maintain the position of their data and not move the border of the ice so that it fits into a political or economic

perspective. Scientists must maintain the premises of science and not listen to what politicians think is opportunistic to them."

-- Paul Wassmann, marine biologist (Norwegian News Agency 2015b)

We began this article with Prime Minister Solberg's statement that 'nature' had moved the ice edge. At one level, this statement can be analysed for its conceptualisation of nature as a distinct, pre-social force whose actions can explain the condition of observable phenomena. Critical theorists of the nature-society relationship have contested this view (e.g. Braun and Castree 2005), but even if one maintains that 'nature' exists as something distinct from the social world Solberg's statement can be critiqued. One can note, for instance, that the 'nature' identified by Solberg has been impacted by emissions from the carbon-based economy that the policy change associated with the relocation of the ice edge is meant to facilitate.[3]

In this article, however, we have focused less on the 'nature' that is ostensibly doing the moving and more on the 'ice edge' that is being moved. In order for the ice edge to be *moved* (by nature or by any other force), it must first be identified as an ontologically stable object, and the ice and open water that represent the two sides of this edge must similarly be identified as distinct elements. As we have shown, this is hardly the case. Although the ice edge has material effects, it is a construction that emerges from a fusion of science, law, policy, and cartography. In short, the ice edge is less a point (or series of points) *in* space – an ontologically stable foreground object that can be mapped against a metric background -- than it is a construction that *defines* space. And, if it defines

space, then what appears to be *movement* is really a moment of discursive reconstitution.

Mobility is not the only property called into question once one removes the ice edge's ontological stability. If the ice edge does not exist as a distinct object, can it ever be said to disappear? Can it go missing? These were the questions asked and implicitly answered in 1930 by Russian oceanographer Nikolai Knipowitsch when he sent his tongue-in-cheek telegram to colleagues. Noting that the ice edge was 'lost', Knipowitsch celebrated that he had correctly predicted that, due to higher temperatures and changes in the Gulf Stream, there would be an almost total absence of sea ice that summer in the Barents Sea.

In a similar vein, one must ask: Once one has endowed the ice edge with the qualities of an *object* that can been seen, observed, moved, and used as a planning tool, what else can it do? Three days after Prime Minister Solberg's remark about nature having 'moved' the ice edge, Norwegian television viewers learned that the ice edge can also generate satire and, in the process, become enlisted in a seemingly unrelated political controversy. On 23 January, one of the hosts of the Norwegian television program Nytt på Nytt fused the ice edge debate with an ongoing search for a Norwegian home for Kurdish Islamicist refugee Mullah Krekar. Mullah Krekar had recently been released from jail after serving a prison term for death threats towards Prime Minister Solberg. Sending him back to Iraq could well result in a death sentence, which would violate Norway's human rights obligations. So, the Nytt på Nytt host satirically suggested that instead of sending Krekar to a remote Norwegian village where he could continue to organize his potential terrorist networks, he should be sent to the ice edge, where he would report several times a week on its exact location.

The irony here is that while it is absurd to imagine Mullah Krekar scientifically determining the precise location of the ice edge, such precision likewise cannot be obtained by the scientists of the Norwegian Polar Institute, the Canadian Ice Service, or any other institution. In the second quotation reprinted above, which was criticising Norwegian Polar Institute director Jan Gunnar Winther for his defence of the 2015 map, Tromsø-based biologist Paul Wassmann contends that ice edge research can and should rise above politics (see also, Krekling 2015). We have argued, however, that the very identification of the ice edge as a distinct boundary and the concomitant designation of sea ice as an object that has *presence* and *significance,* and that can therefore be used for spatial planning, is itself embedded in politics. Drawing on fieldwork with the indigenous peoples of northwestern Greenland, anthropologist Kirsten Hastrup (2016) has called ice 'sociable' (see also Bravo 2010). Similarly, from their research on glaciologists Carey *et al.* (2016) have designated ice as 'gendered'. Our studies from Norway and Canada suggest that when ice is mapped by the state it is not only *sociable* and *gendered*; it is *political*.

To conclude, we do not entirely reject the stories of the ice edge told by those who make and use maps that feature its depiction. The ice edge that was lost by Nikolai Knipowitsch and later found by Prime Minister Solberg had indeed been 'moved' by nature, even if, in the latter instance, nature had been assisted by anthropogenic climate change. Likewise, we do not question Denis Dubé's assertion that the shift to the 30-year median on the new Canadian map is in fact a progressive change because it presents a better baseline that can be used for assessing future changes in Arctic sea ice and that ultimately can be used to provide a more critical perspective on climate change, its effects and, by

inference, its causes. However, so long as officials and activists – in Norway, Canada, and elsewhere – persist in efforts to map the unmappable, reducing the temporal and spatial complexity of ocean-atmospheric processes to singular representations, these maps, and the elements enrolled in the process of mapping, will take on a political significance that exceeds their specific signification about the geophysical properties of space.

The solution is not necessarily to abandon the map as a planning tool. Numerous works in critical cartography have demonstrated how alternate knowledges, applied from perspectives other than the idealised Euclidean space of solid land and linear time, have led to different kinds of maps that have permitted different kinds of spatial planning, reflecting the politics and views of peoples (whether or not indigenous) who encounter space as fluid and dynamic (Sletto 2009; St Martin 2005). Rather, the histories of the Norwegian and Canadian ice edge maps, and the two countries' broader histories of ice quantification, caution us to remain critical not just about *where* borders are mapped in complex environments but also about *what* is mapped at all.

Due to its inherent variability and indeterminacy, it is impossible to achieve the kind of state-of-the-art scientific mapping of the ice edge proposed by Wassmann. Indeed, such a mapping may not even be desirable, as it would assign a false ontological stability to the socially constructed, arbitrarily delimited, and spatio-temporally variable states of solid ice and liquid water. However, so long as ice remains embroiled in the will to map, the ice edge will remain a potent player in the efforts of scientists and statespersons to write power to the world.

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Endnotes

[1] All Norwegian-language quotations, including this one, have been translated by the authors. Government documents that were simultaneously released in Norwegian and English are noted as such in the reference list. In these instances, quotations are from the English language version. Norwegian language maps (Figures 1 and 4) are reproduced in original Norwegian because their main purpose in this article is to evidence Norwegian depictions of sea ice rather to aid readers in finding precise locations.

[2] See also the summary provided to Parliament that integrated findings from the series of 2003 reports (Ministry of Petroleum and Energy 2003).

[3] In fact, in the report that accompanied the 2015 map, the Ministry of Climate and Environment (2015a, 26) noted that future ice-cover in the Barents Sea is critically dependent on the level of global greenhouse gas emissions.

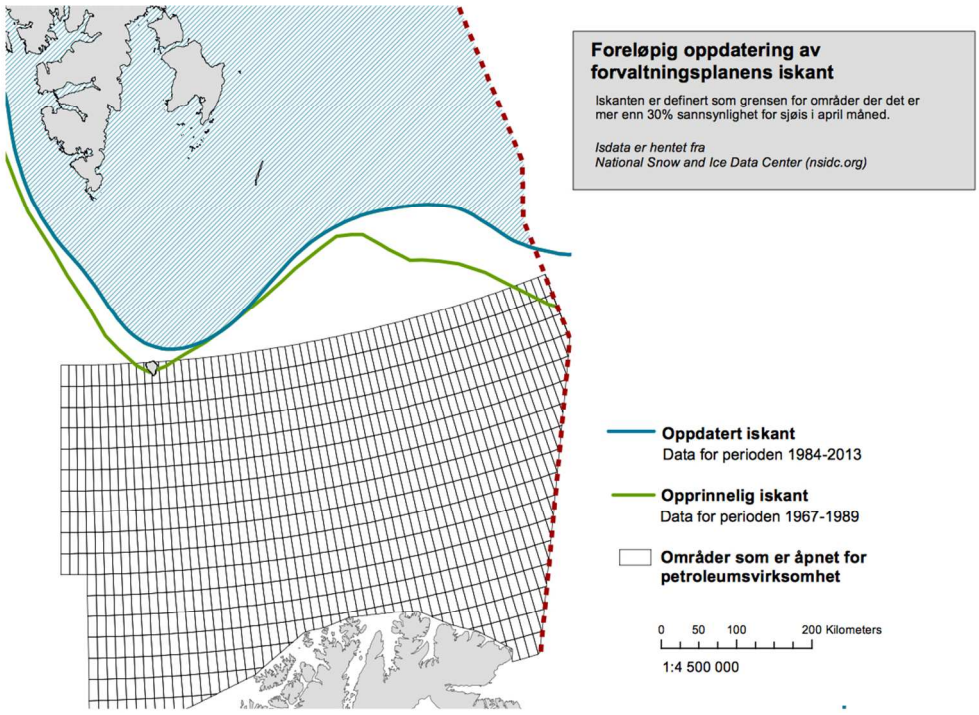

Figure 1: Map released by the Government of Norway, January 2015, indicating previous and revised locations of the ice edge, as well as Norway's Southeast Barents Sea Offshore Oil Province (Ministry of Climate and Environment 2015b). Reprinted with permission of the Norwegian Ministry of Climate and Environment.

Translation of Norwegian text is as follows: Grey textbox: 'Preliminary update of the management plan's ice edge – The ice edge is defined as the boundary of the area where there is greater than 30% probability of sea ice in April. Ice data retrieved from National Snow and Ice Data Center (nsidc.org)'; Blue line: 'Updated ice edge – Data for the 1984-2013 period'; Green line: 'Original ice edge – Data for the 1968-1989 period'; White outline: 'Areas open for petroleum activities'.

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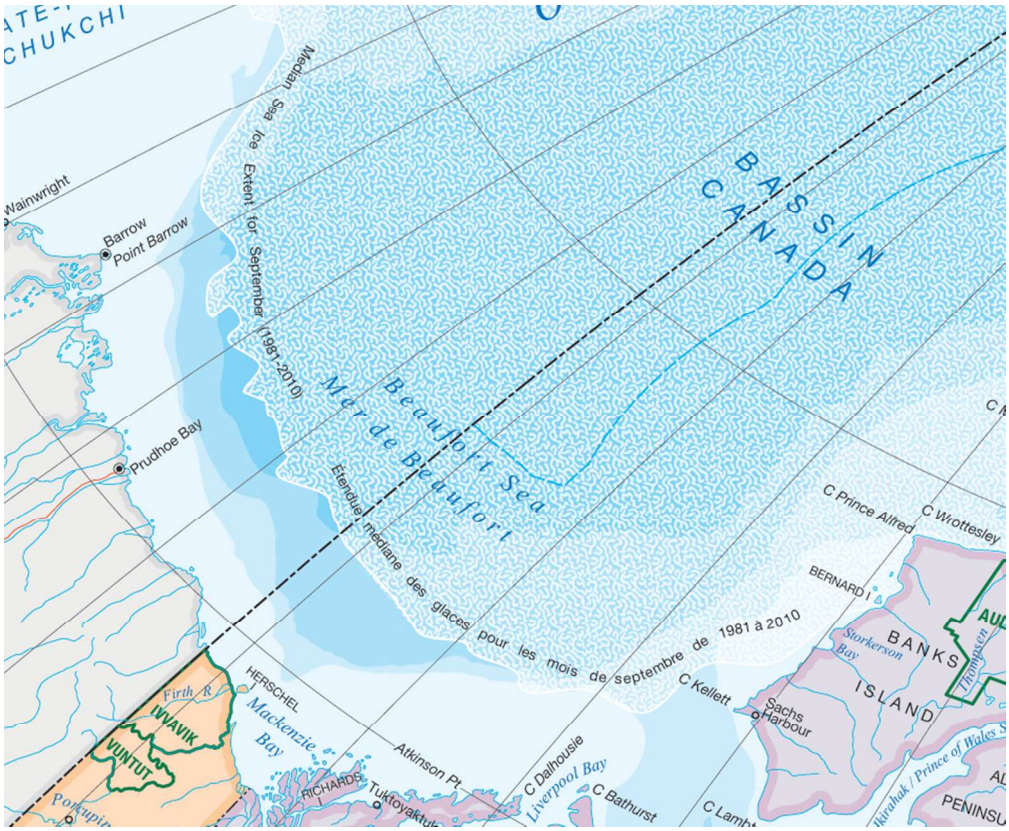

Figure 2: Detail from the national map in the 2015 edition of the Atlas of Canada, depicting the 'Median Sea Ice Extent for September (1981-2010)' (Natural Resources Canada 2015a). Reprinted courtesy of Open Government Licence - Canada.

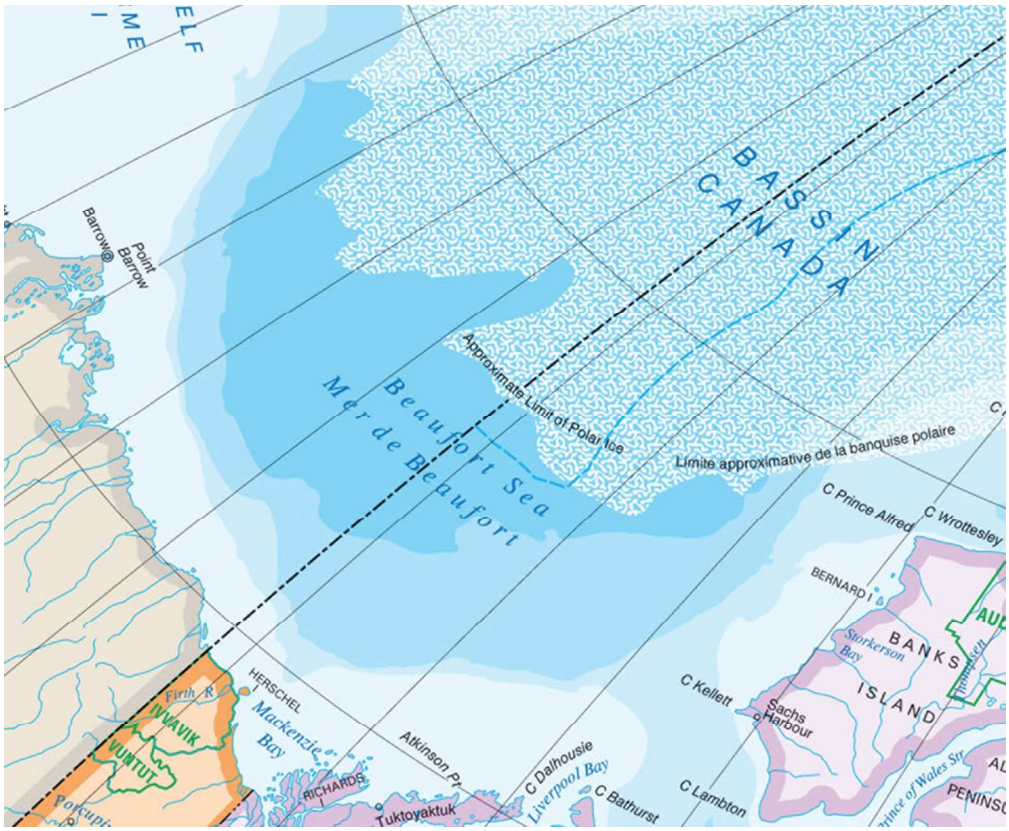

Figure 3: Detail from the national map in the 2006 edition of the Atlas of Canada, depicting the 'Approximate Limit of Polar Ice' (Natural Resources Canada 2006). Reprinted courtesy of Open Government Licence - Canada.

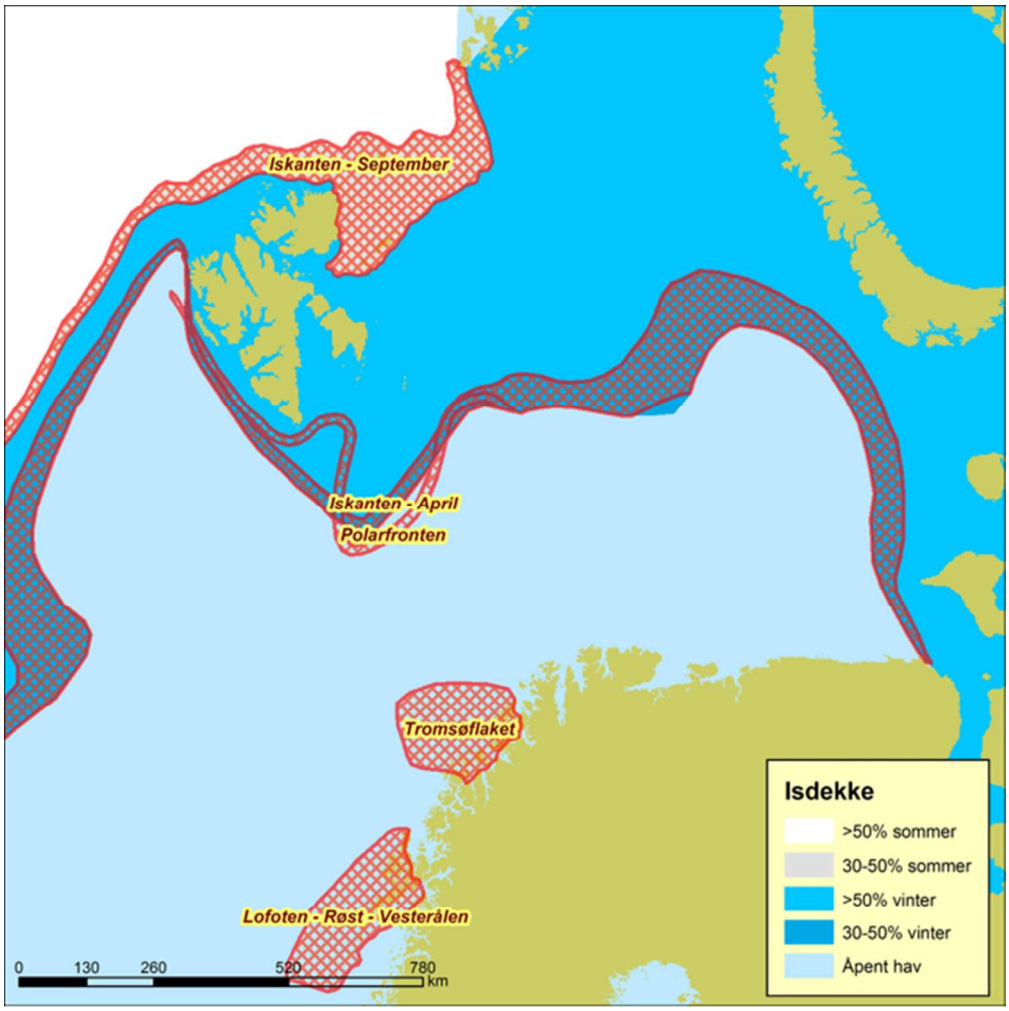

Figure 4: Figure from The Identification of Particularly Valuable Areas in Lofoten – Barentshavet (Olsen and von Quillfeldt 2003, 62). Reprinted with permission of the Norwegian Institute of Marine Research.

The four 'especially valuable areas' that crucial to supporting the region's biodiversity are identified on the map with red hatching, from south to north: (1) Lofoten – Røst – Vesterålen, (2) the Tromsø sheet (Tromsøflaket), (3) the Polar Front (Polarfronten), and (4) the September (minimum) and April (maximum) ice edges (Iskanten). Translation of Legend: 'Ice cover: >50% Summer; 30-50% Summer; >50% Winter; 30-50% Winter; open water'.

226x226mm (72 x 72 DPI)

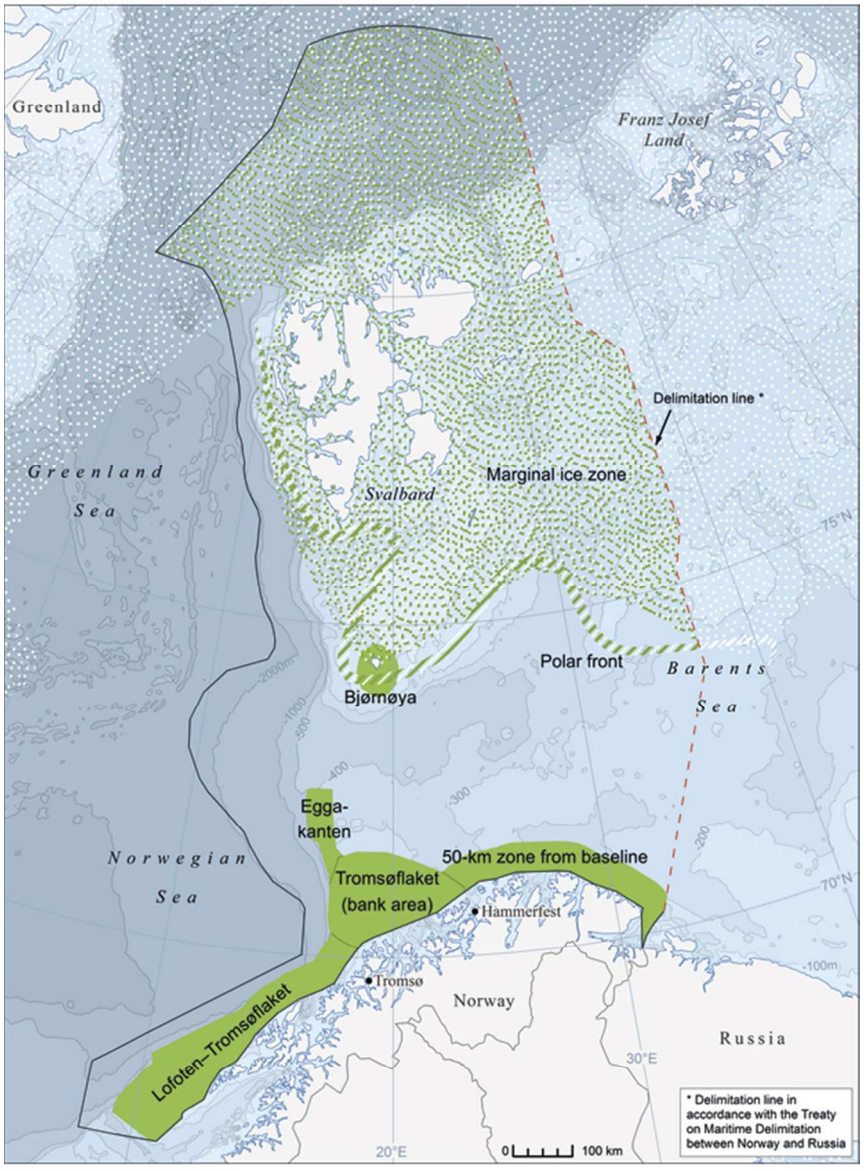

Figure 5: Particularly valuable and vulnerable areas in the Barents Sea – Lofoten area (Ministry of the Environment 2011, 24). Reprinted with permission of the Norwegian Ministry of Climate and Environment.

218x306mm (72 x 72 DPI)