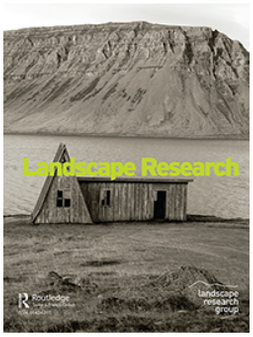

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Mapping ice in the Norwegian Arctic – on the edge between science and policy

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ABSTRACT

In the Norwegian Arctic, petroleum exploration is prohibited north of the ice edge (the zone between solid sea ice and open ocean); the mapping and definition of the ice edge becomes the boundary for petroleum exploration. However, no evidence-based scientifically 'correct' position of the ice edge exists. Defining the ice edge—and its geographic positioning—is the result of co-production processes involving multiple actors and practices. We explore how the use of a new dataset for determining the geographical position of the ice edge became the centre of a proxy debate over how far north petroleum exploration should be allowed. The analysis reveals how maps serve as visual discourses in debate, and a strong correlation between different definitions of the ice edge and political commitment to petroleum activities. We challenge and discuss the performativity of maps and how mismatches between expectations to knowledge-based management, including maps, may have democratic implications.

KEYWORDS

Ice edge; critical cartography; STS; maps

Co-producing the ice edge

On 20 January 2015 two events took place: The Ministry of Petroleum and Energy announced the 23rd licencing round for oil exploration on the Norwegian Shelf and the Ministry of Climate and Environment announced that it would update the source data generated to map the ice edge in the Barents Sea. Is the fact that these events took place on the same day a matter of coincidence? Hardly, because they are connected. More specifically, they both relate to the geographical positioning of the ice edge. In the months that followed, politicians from both the right-wing and left-wing parties and numerous environmental NGOs participated in a heated public debate over the geographical location of the ice edge, as if the issue of defining the ice edge were a political decision of national significance rather than an objective scientific description of 'what is' (Bay-Larsen & Hermansen, 2015).

The ice edge—or marginal ice zone—is the zone that demarcates open water from sea ice. Based on a scientific quest for truth and definition(s) of a given phenomenon, researchers can produce definitions of the ice edge and its geographical position. Oceanography, meteorology and remote sensing make it possible to observe the location of the ice edge at any given time. In the integrated management plans for the Barents Sea and Lofoten area, these observations are shown as a line on a map or, more precisely, as multiple lines on multiple maps. Two scientific papers have already provided valuable analyses of how the ice edge debate can reflect fundamental structures of environmental decision-making. In their paper from 2018, Veland and Lynch (2017) describe how multiple knowledge systems are—or are not—integrated into and narrated in the debate, and how this can be perceived as a desire for ontological security by the actors involved. In their paper on the

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same ice edge debate, in which they also compared the Norwegian debate with a parallel Canadian debate, Steinberg and Kristoffersen (2017) provide a thorough genealogy of the multiple maps that come into play, and how these are entangled in petroleum policies and legal or bureaucratic categories, though in very different ways in Norway compared to Canada. They also describe how static ontologies fall short when connected to an environment of extreme spatio-temporal dynamic like the ice edge zone. Rather, the fixed and static categories on the map should be perceived as boundary objects and policy discourses. Ice is political, these scholars state.

In this paper, we build on insights from these scholars and complement them with document analyses and qualitative interviews with key actors, advancing and cross-fertilising between current debates in science and technology studies (STS) and critical cartography. We expect digital maps to become even more fundamental to environmental policies and natural resource management in the future (Bay-Larsen, 2014). We therefore seek to discuss the challenges, dilemmas and paradoxes associated with using maps as tools in democratic decision-making. This article will provide such a contribution by analysing a case of vital significance to a petroleum-producing country that has set high environmental and climate ambitions and expressed an objective to practice knowledge-based management of the highly vulnerable area around the marginal ice zone in the Barents Sea.

We study the debate over the geographical positioning of the ice edge and how the maps that were developed over time reflect political and economic conflicts of interest. The main question raised is: how were maps co-produced and mobilised in the public debate over petroleum exploration in the Barents Sea? Put briefly, the analysis shows that the various maps form a visual discourse consisting of a variety of definitions, actors, datasets, sectors and understandings of water, ice and petroleum. We conclude by discussing the ways in which mismatches between expectations to science and the application of science may have democratic implications, and how transparency and participation in knowledge-based management can address this issue with the use of maps.

Geodata and maps in Norwegian environmental governance

Mapping of natural resources, phenomena and species has acquired a key role in Norwegian environmental governance, including resource management, protection of biodiversity, habitat types, climate change, the Arctic, and land-use planning.[1] It is an effective means of providing the best available information for decision-makers since visual representations can communicate complex natural and landscape assets in a way which written documentation and scientific reports cannot. A map forms a basis for prioritising between a broad spectrum of natural, economic and social assets within a specific area. This makes it relevant to discuss the growing use of geographic information systems (GIS) from the perspective of policy processes and public debate.

The most important functions of a map are to combine information on a spatial object and its attributes, and for digital maps; to compile geodata from multiple knowledge bases and platforms. The Norwegian Polar Institute (NPI) is Norway's governmental institution for mapping and for conducting practical as well as scientific studies in the polar regions. Like the Norwegian Environment Agency, the Directorate of Fisheries and other government agencies, the NPI places a heavy emphasis on map solutions based on data obtained from various professional systems and databases, including downloading services, online or cloud solutions, spatial databases, data modelling and advanced GIS analyses.[2] Today's digital map access solutions also facilitate interactive quality assurance of map data in, for example, terrestrial biology, where mapping of species is conducted in close cooperation with voluntary organisations and individuals (Bay-Larsen, 2014).

The quality of maps can be related to at least four dimensions. First, converting three-dimensional, dynamic nature into two-dimensional, static images requires extensive simplification of ecological or oceanographic phenomena. Many oceanographic phenomena, including the ice edge, are not static in time and space; rather, they appear, move and disappear within a relatively short space of time. Because of its dynamic character, the ice edge simply cannot become ontologically stable (Steinberg & Kristoffersen, 2017). Defining scientific uncertainties associated with

knowledge acquisition—data sources, measuring instruments—is therefore highly volatile and relative. Second, digital maps also vary in terms of digital and technological standards and formats. Third, quality is relative to the intended purpose of the data; that is, whether maps are supposed to visualise impact factors, or the state of a given environment. Finally, maps are always adapted to a legal and administrative framework. For example, value-based map services related to environmental protection are delimited for use as legal instruments, defining inside and outside a protected area. Maps of blocks developed for exploratory petroleum drilling in the Barents Sea are based on datasets that have built-in premises originating in the Petroleum Act[3] and the integrated management plans for the Barents Sea and Lofoten area. In other words, what a map represents and what purpose it was designed for will have a decisive impact on its quality.

Map quality cannot, however, be visualised in a simple manner, which makes it difficult for non-experts to assess the quality of a map. If a map is 'wrongly' interpreted or used in the wrong context, any decisions made will be based on incorrect premises. It is therefore relevant to discuss the use of GIS in knowledge-based management, how maps can generate different perspectives, and what role technology, institutions and networks play in quality assuring knowledge.

Theoretical concepts: bridging cartography and STS

In this article we employ a conceptual framework that links three key concepts from science and technology studies (STS)—formalisation, separation (Sundqvist et al., 2015) and performativity (Asdal, 2015)—to debates in cartography. The first term, *formalisation*, concerns scientific methods, procedures and underlying ontological and epistemological premises: what is the truth, and how can we make sure we capture it? *Separation* concerns the organisation of scientific work: who participates in the production of expert knowledge? A policy process founded on external expertise will make it easier for citizens to acquaint themselves with public administration assessments and decisions. A classic argument in this debate is therefore that scientists should be separated from the domain of public administration and policymaking until scientific consensus has been reached, to avoid politicised conclusions (Haas & Stevens, 2011). Scientific expertise lends legitimacy to policy because politicians can point to something that is separated from the value-based and subjective sphere (Wilson, 2010). Expert knowledge may also contribute to enhancing transparency and democracy by documenting the rationales on which policy decisions are based (Dawes, 2010). This may explain why proponents of knowledge-based management in environmental policy and administration often base its arguments on a positivist scientific tradition and on a high degree of formalisation and separation (Sundqvist et al., 2015). In short, it may be argued that scientific knowledge has the power to support and legitimise policies (Hogl et al., 2012). Consequently, it may become a strategic pawn in political disputes involving strong conflicts of interest (Bjørgo & Bay-Larsen, 2017).

Maps were long understood to be objective, neutral and representative; the surface of the earth should be represented as faithfully as possible (Kitchin & Dodge, 2007). Critical cartography on the other hand—a clear parallel to STS—has demonstrated how maps are contingent, relational and context-dependent (Kitchin et al., 2013), and are constituted in and through diverse discursive and material processes. In this literature, the power of maps is not only associated with their being representational objects, because maps also shape, perform and enact the world (Del Casino & Hanna, 2006; Perkins, 2017; Steinberg & Kristoffersen, 2017). The production of counter-mappings was made visible, including how maps were shaped by diverse interests to provide alternative viewpoints to state-sanctioned and commercial cartography (Hongslo, 2017; Kitchin & Dodge, 2007; Harley, 1989). According to Asdal (2015), documents and illustrations contribute to modifying and transforming reality, referred to as *modifying work*. In the map creation process, subjective decisions are made about what to include, how the map should look, what it should communicate, and so on (Caquard, 2015). In other words, maps not only represent and reveal the world, they also help create that view of the world into being. Put differently: maps and documents are *performative* (Asdal, 2015) and cannot be seen as separated from policy realms (Sundqvist et al., 2015).

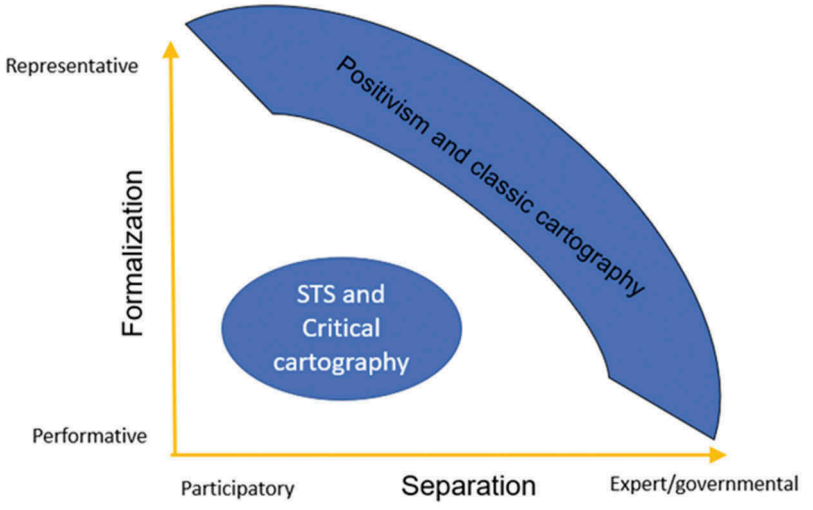

Figure 1. Elaboration of Sundqvist et al. (2015) and Bay-Larsen et al (2019) with a focus on key concepts in cartography; the maps as representative or performative, as co-produced or developed through science and expert knowledge.

It is therefore crucial to understand the processes by which maps become issues, contribute to shaping issues, and—not least—the effects these processes have. This article draws on these insights, and on how maps represent visual discourses: spatial practices enacted to resolve relational problems (Hongslo, 2017). We see them as arguments in spatial management debates where different maps may speak in different tongues. This multivocality, or multienactment, constitutes some of their most powerful effects, as they may contribute to the disclosure of things or not (Hongslo, 2017; Crampton, 2009).

In Figure 1 we illustrate two main stances in the parallel debates in science policy studies and cartography: 1) positivism and classic cartography, arguing for the objective and independent character of maps and documents, and 2) STS and critical cartography linked together, emphasising the contingent, co-producing and performative character of documents and maps. The vertical axis depicts the dimension of formalisation in the original work by Sundqvist et al. (2015). Adapted to our framework, we place *representation* on the top of the axis, while the STS argument about the inevitable importance of judgement (Collins, 1985/1992), signifying the contextual and *performative* character (Asdal, 2015) of maps is placed on the bottom. Separation is placed along the horizontal axis. The ideal of a strong degree of separation between expert knowledge/science and public policy is placed on the far-right end, while the stance on integration of science and policy is placed on the far-left end of the dimension, denoting that expert knowledge/science and policy are inevitably co-produced (Jasanoff, 2004).

Sundqvist et al. (2015) argue that in some instances a mismatch can arise between one's *declared* position in this landscape and one's *actual* position, particularly in heated political debates involving strong conflicts of interest over using or protecting oil, climate or the environment (Sundqvist et al., 2015). This *mismatch* can be upheld by a general expectation in society of science to provide objective and neutral facts and evidence. If these expectations are not confirmed, the legitimacy of policy and the credibility of science may decay. Thus, scientists and politicians share an interest in presenting science as formalised and separate. In the analysis, we will shed light on and discuss these tensions, employing the concepts of *formalisation, separation, performativity* and *mismatches*. Linking together the concepts from cartography and STS and cross-fertilising in this manner will enable us to harness the analytical force of formalisation/separation framework to advance current debates in cartography, and to simultaneously further develop the formalisation/separation framework.

Data and sources

The power and discursive ability of maps are in our study revealed through empirical investigations of the production and use of different maps of the Barents Sea over a period of more than ten years.[4] Document analysis and semi-structured interviews with scientists, bureacrats, politicians and NGOs constitute the methodology used in this paper, with parts of the empirical data based on Bjørndal (2016). Quotes from Bjørndal (2016) have been translated from Norwegian into English. The documents used include white papers, press releases, reports and hearings.

The visual discourse of the marginal ice zone

How were maps mobilised?

The first mention of the marginal ice zone in government documents came in the first management plan for the Barents Sea and Lofoten area from 2006 (Figure 2, left). Here the marginal ice zone was marked with an orange line and described as 'a particularly productive ecosystem within the Barents Sea' (St. meld. nr. 8, 2005–2006, p. 31).

In the next white paper—the first update of the integrated management plan for the Barents Sea and Lofoten area published in 2011—the map appeared to be the same as in the 2006 integrated management plan only with an updated layout (Figure 2, right). On this map the ice edge was indicated as a blue line at the top of the figure (the thickest and least curved of the two lines and marked 'Iskanten'). Nonetheless, these documents gave no detailed textual definition of the ice

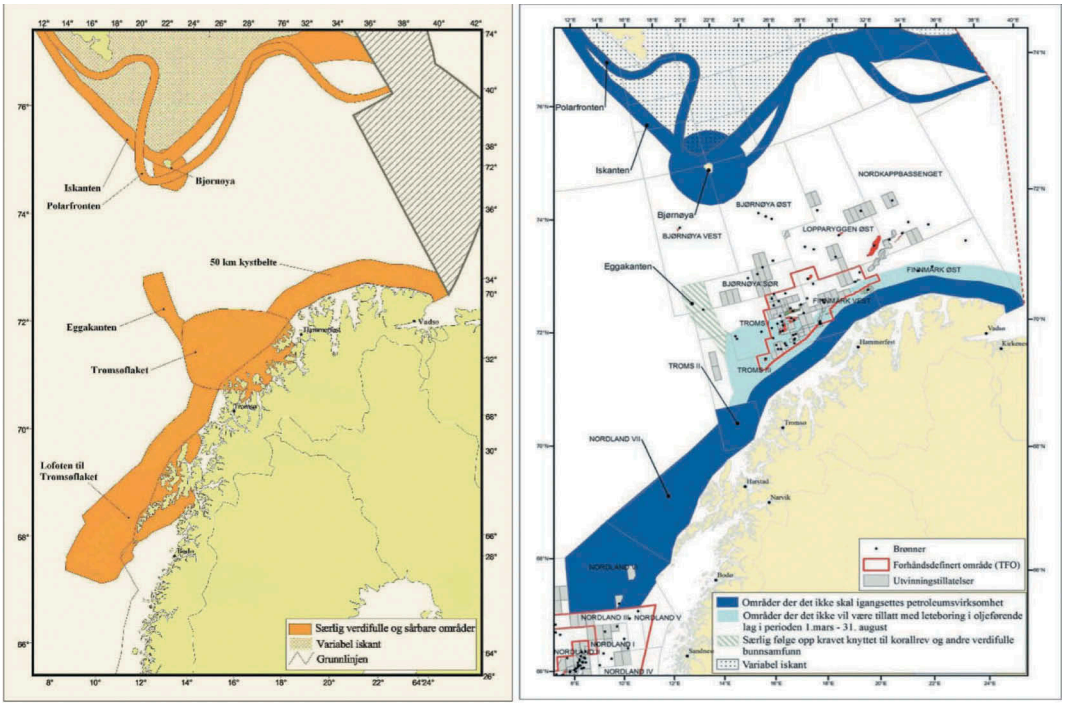

Figure 2. The ice edge illustrated in the first and second management plans for the Barents Sea–Lofoten area 2006 (L-R:.St. meld. nr. 8, 2005–2006, p. 31; Meld. St. 10, 2010–2011, p. 131). The orange and blue areas represent vulnerable areas where petroleum production is not allowed. The ice edge is the orange and blue line in the upper part of the maps marked "Iskanten" (the thickest of the two lines). In the map to the right you can also see areas approved for petroleum activity as well as the outer line of the new Barents Sea South-East area (red dotted line in the right upper part of the map). The area open for petroleum activity is more visible in Figure 3.

edge, which had not yet become a key pawn in the discourse on oil exploration in the Barents Sea. Two years later, the white paper that opened for oil exploration in the south-east areas of the Barents Sea (Meld. St. 36 (2012–2013)) was published, including a supplementary report which reportedly corrected an error in the printing process. Note that here, the Barents Sea South-East refers to the south-eastern parts of the Norwegian part of the Barents Sea, after the demarcation of the area was agreed upon with Russia, see Figures 3 and 4. The supplementary report stated:

> No petroleum activities shall be initiated in the areas by the ice edge and the polar front. The issue of petroleum activities by the ice edge and polar front will be reviewed in connection with the next update of the management plan for the Barents Sea. This does not preclude petroleum activities from being conducted in the entire Barents Sea South-East. (Meld. St. 41 (2012–2013), p. 12)[5]

This implied that the ice edge was not located in the Barents Sea South-East: petroleum activities were not to be conducted by the ice edge, but this did not preclude petroleum activities from being conducted in the entire Barents Sea South-East. The Ministry of Petroleum and Energy announced this in 2013, at a time when the applicable management plan for the Barents Sea and Lofoten area, published by the Ministry of the Environment, suggested the contrary, namely that the ice edge was located within the Barents Sea South-East.

This was the backdrop when the Ministry of Climate and Environment announced on 20 January 2015 that it would update the dataset used to map the ice edge in the Barents Sea, on the same day as the Ministry of Petroleum and Energy announced the 23rd licencing round for oil exploration on the Norwegian Continental Shelf. In this round, 34 of 57 proposed blocks were located in the Barents Sea South-East, 20 in the remaining parts of the Barents Sea, and three in the Norwegian Sea (Olje- og energidepartementet, 2015). Based on the new dataset, a map was

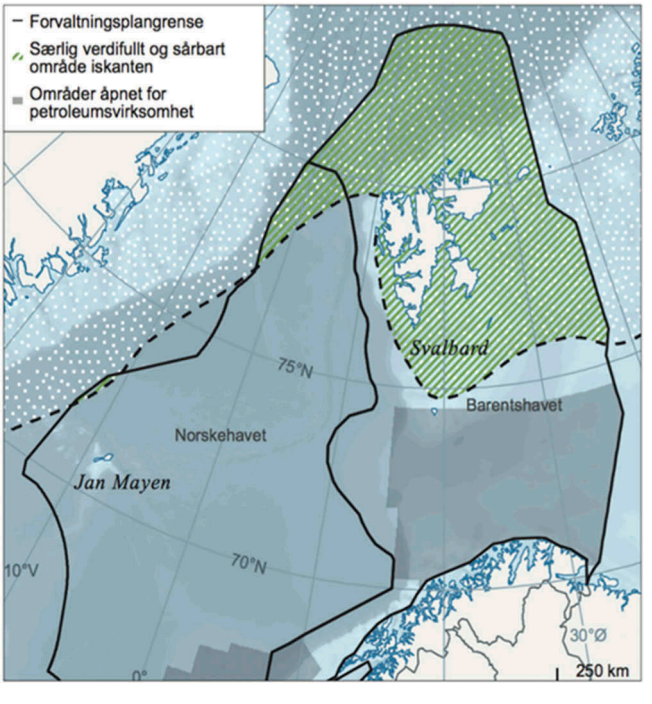

Figure 3. The ice edge as illustrated in Meld. St. 20, 2014–2015, p. 37) shows that there is no ice in the area opened for petroleum activity. The grey shaded area represents the area where petroleum activity is allowed, including the new Barents Sea South-East area to the right (this area is highlighted in Figure 4). The black lines indicate the zoning area limits, with the right part of the two areas being the Barents Sea. The green lined area represents the ice edge.

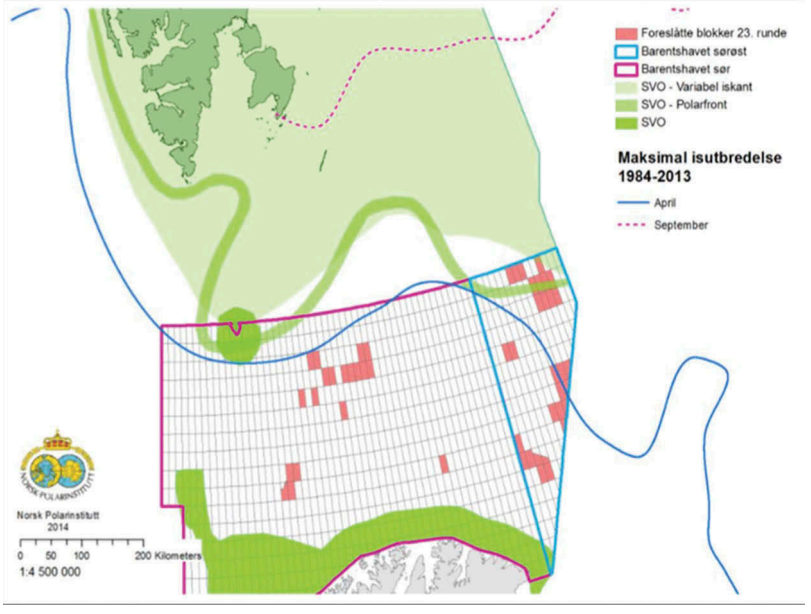

Figure 4. Map from NPI, showing the maximum ice limit (Winther and Berthinussen (2014).

produced which clearly showed that petroleum activity could be conducted throughout the Barents Sea South-East without coming into conflict with the vulnerable marginal ice zone (see Figure 3).

The final map that mapped this line and that was brought into the debate came from NPI (Figure 4). It was produced in 2014, but used frequently in the debate, especially after the map from the Ministry of Climate and Environment was published a year later. This map related to the 23rd licencing round and was thus produced before the map from the Ministry of Climate and Environment. NPI published two documents dealing with the ice edge: the consultative statement regarding the 23rd licencing round mentioned above (Winther & Berthinussen, 2014), and a memo discussing the ice edge that was to serve as the basis for the updated management plan of 2015 (Norsk Polarinstitutt, 2014).

The consultative statement used the maximum ice limit to describe the ice edge, as shown in Figure 4. NPI concluded that, *inter alia*, four of the blocks announced in the licencing round affected the areas of the polar front[6] and variable ice edge (Winther & Berthinussen, 2014, p. 3).

The ensuing debate over the maps and the definition of the ice edge can be understood as a visual discourse and exchange of views where key actors used different maps as a basis for advancing a specific political position. The following sections give a more detailed account of how this discourse was shaped by various claims regarding the scientific definition of the ice edge. Furthermore, the analysis shows which actors were behind the various definitions.

Four maps, four definitions

The ice edge was mapped in the management plans for the Barents Sea and Lofoten area from 2006, 2011 and 2015, and in documents related to the call for the 23rd licencing round in 2015. Up until 2015, however, the actual definition of the ice edge drew no political attention. The previous management plans from 2006 and 2011 only described the ice edge in the form of a figure (Figure 2). Lars Andreas Lunde, former state secretary in the Ministry of Climate and Environment, stated in an interview that although no written definition had been formulated in the two previous management plans, it was known inside the ministry which definition was used: 'I didn't know about the definition until I came here to the ministry. [. . .] It was known inside the ministry, but not in the

Storting'[7] (Bjørndal, 2016, p. 44 (our translation)). In a parliamentary debate Heikki Holmås stated: 'Never before have we discussed the definition or anything else. We have discussed this map, and that is what we included. [. . .] The maps show that several blocks in the 23rd licensing round are in conflict with the ice edge and the polar front' (Bjørndal, 2016, s. 80 and 83, author's translation). Here, Holmås is referring to the maps from the two previous management plans from 2006 and 2011.

In other words, there was disagreement over whether a definition had in fact been adopted. This caused further disagreement over what the definition was and—more importantly—what it *should* be. In the updated management plan from 2015, however, and in interviews from Bjørndal (2016), it emerged that the data used in the management plans from 2006 and 2011 dated back to the period 1967–1989 (except 1976), although this was not clearly stated in the documents. This can be seen in the scientific basis for the first management plan.

Table 1 provides an overview of the definitions used in the first two management plans and subsequent definitions, as well as their originators. Implementation of any of these four definitions would effectively change the areas allowed for petroleum activity, making them important for the different actors within the controversy. The different definitions and their locations on the map are described below.

Definition 1: the 30-per-cent-limit

The first definition is illustrated in the two management plans for the Barents Sea and Lofoten area from 2006 and 2011 and refers to areas where there is ice for 30 per cent of the days in April, measured from the normal period 1967–1989 (Bjørndal, 2016; St. meld. nr. 8, 2005–2006, p. 31; Meld. St. 10, 2010–2011, p. 131).

Definition 2: the maximum ice limit

The second definition is from the Norwegian Polar Institute (NPI), which is the official provider of knowledge on polar issues to Norwegian authorities, and refers to the maximum ice limit (Norsk Polarinstitutt, 2014: Winther & Berthinussen, 2014). A memo from NPI discussing the ice edge described how it was more appropriate to use the minimum and maximum ice limits to describe the ice edge because they said something about 'where the limit really lies and, together with ice frequency, how the limit changes over time' (Norsk Polarinstitutt, 2014, p. 6; Bjørndal, 2016). The minimum and maximum sea ice extent refers to the extent of ice (15 per cent or more during a given period) (Norsk Polarinstitutt, 2014). *Ice frequency* says something about how many days during a given period there is ice in a specific area. A sea ice frequency of 10 per cent during a period of 100 days means that sea ice occurred in the area on 10 of the 100 days. Ice frequency indicates that ice occurred in an area but says nothing about *how much* ice occurred (Bjørndal, 2016).

Dag Vongraven, senior adviser at NPI, explained that it was completely logical for NPI to use maximum sea ice extent, zero-per-cent ice frequency, as opposed to 30 per cent ice limit, and that it was important to distinguish between expert and political assessments: 'Professionally speaking it is

Table 1. Actors and their definitions of the ice edge, according to Bjørndal (2016).

Definition	Originator
Where there is ice for 30 per cent of the days in April, 1967–1989 (except 1976) (ice concentration greater than 15 per cent)	The first two management plans for the Barents Sea South-East (Meld St. 8, 2005–2006, p. 31; Meld. St. 10, 2010–2011, p. 131)
Maximum sea ice extent for the preceding 30 years (ice concentration greater than 15 per cent)	Norwegian Polar Institute
Where there is ice for 30 per cent of the days in April, measured over the preceding 30 years (ice concentration greater than 15 per cent)	Management plan from 2015 (Meld. St. 20, 2014–2015)
The actual/observed ice edge (wherever the ice edge is located at any given time)	Used mainly by Ministry of Petroleum and Energy (Meld. St. 41 Tilleggsmelding til Meld. St. 36 (2012–2013)), but sometimes also by the Ministry of Climate and Energy (Meld. St. 20, 2014–2015).

totally logical to use a zero-per-cent ice frequency. [. . .] We have to draw a clear distinction here between expert judgment and a political assessment' (Bjørndal, 2016, p. 67 (our translation). This clearly reveals that NPI deemed it professionally sound to use the maximum ice limit instead of the 30-per-cent-limit that was actually used.

Definition 3: the updated 30-per-cent-limit

In the updated management plan from 2015, the marginal ice zone is defined as the area where sea ice occurs for 30 per cent of the days in April, based on satellite data from 1985 to 2014 (Meld. St. 20, 2014–2015, p. 36):

> The marginal ice zone as a particularly valuable and vulnerable area is defined so that it encompasses the whole area within which the marginal ice zone will normally be found as the sea ice extent varies between its annual maximum and minimum. The boundary of the marginal ice zone is considered to follow the line where sea ice is present on 30% of the days in April, using a time series of satellite observations of ice extent for the 30-year period 1985–2014. The criterion for determining whether ice is present is an ice concentration exceeding 15%, meaning that ice covers more than 15% of the sea surface. This is in accordance with international standards. This frequency measure is called 'ice persistence', and in the short term it expresses the probability of finding sea ice in the period for which the calculations have been made.

This is a variation on the 30-per-cent limit mentioned in Definition 1. This definition is based on measurements for the preceding 30 years, in this instance 1985–2014 instead of 1967–1989 as in Definition 1 (Meld. St. 20, 2014–2015.

Definition 4: the observed ice edge

A fourth definition of the ice edge was given in the same updated management plan from 2015: 'In accordance with the framework for the 23rd licensing round approved by the Storting, restrictions are set on when exploration drilling is permitted along the actual/observed ice edge (wherever the ice is located at any time)' (Meld. St. 20, 2014–2015, p. 44 (our underlining and translation)). This definition refers to the location of the ice edge at any given time and is mainly used by the Ministry of Petroleum and Energy, but sometimes also by the Ministry of Climate and Environment (Meld. St. 41 Tilleggsmelding til Meld. St. 36 (2012–2013)).

Different lines on the map

These different definitions of the ice edge result in different lines on the map, and thereby different possibilities for petroleum activity. The thin green line in Figure 5 illustrates Definition 1, the 30 per-cent limit from the previous management plans which were based on data from 1967 to 1989. Here one can see how this definition would collide with the proposed blocks, marked light red in the grid. The darker blue line illustrates Definition 2, the maximum ice limit for April for the years 1984–2013. This runs far deeper into the area proposed for petroleum exploration, and if it were to be used, it would conflict with other blocks. Dag Vongraven at NPI explained that using a maximum ice limit was a professional decision on their part: 'What we in fact say is that, from a vulnerability perspective, there should be no oil activity wherever there is ice' (Bjørndal, 2016, p. 67 (our translation)). Furthermore, the NPI memo stated that the 30-per-cent-limit said nothing about the variation during the month, and that it therefore provided no information on the location of the ice edge during that same period (Norsk Polarinstitutt, 2014, p. 6).

Definition 3 proposes using measurements from the preceding 30 years. This means one would expect having to refer to a new line every year. This definition is illustrated by the black dotted line and the light blue line. These lines illustrate the ice edge for the periods 1985–2014 and 1984–2013, respectively. As the figure shows, these two time periods differ significantly, and consequently have direct significance for policy and management. Both data periods deviate from the 30-year periods typically used in meteorology and climate science. The current 30-year period runs from 1961 to 1990 and will change in 2020 to run from 1991 to 2020. In a world that is already affected by climate change, there are professional arguments to support the view that using the floating 30-year period

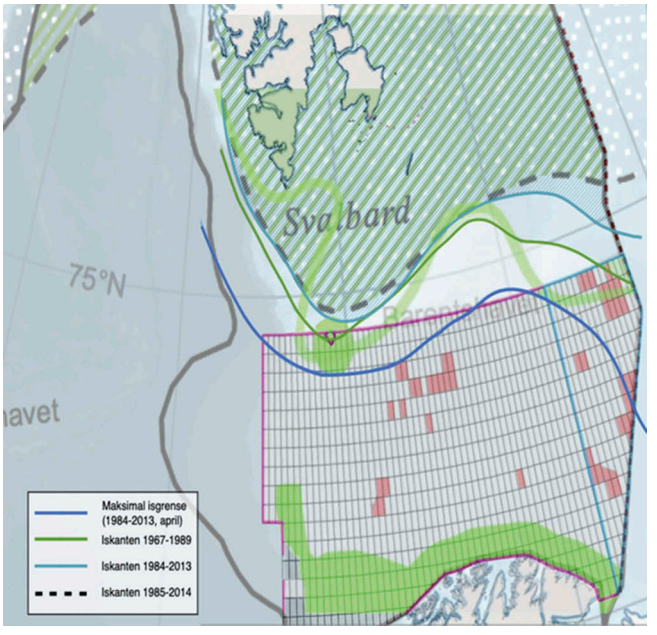

Figure 5. The above map illustrates the different definitions of the ice edge. Based on Bjørndal (2016) and maps in Meld. St. 20, 2014–2015, p. 35, Klima- og miljødepartementet (2015) and Winther and Berthinussen (2014).

from the updated management plan may better illustrate today's realities. Nonetheless, one may question why this amendment was made at precisely this point in time. The actual/observed ice edge (Definition 4) was not drawn on the map shown in the figure; the fact that it changes by the hour and by the day makes it difficult to draw on a map, also indicating how challenging it is to use in management plans.

The 'competing' maps prompted a heated political debate over the knowledge base underlying the maps, the range of the datasets and, not least, the scientific definition of the ice edge. This happened because conflicting scientific definitions of the ice edge were proposed, not only by opposing parties and organisations but also by government ministers and ministerial staff.

Co-production of maps: blurring the lines between science and policy

The proactive politicians

The maps derived from the four definitions of the ice edge were developed and used as arguments in the debate over oil exploration in the Arctic. The government's proposal to update the datasets prompted engagement from several actors. Opponents of oil exploration, such as the Liberal Party and the World Wildlife Fund Norway, adhered to NPI's definition. Ola Elvestuen, then chair of the Standing Committee on Energy and the Environment in the Storting, said in an interview: 'We took the one [factual basis] we had, which was the Polar Institute's consultative statement on the 23rd licencing round' (Bjørndal, 2016. p. 57 (our translation)). Nils Harley Boisen from the World Wildlife Fund Norway said that, in its consultative statement on the 23rd licencing round, the NPI had created a new definition for where the limit should go: 'When you see that they advise against all the blocks more or less north of a line they drew on a map, then they implicitly created a new definition of where the limit should go' (Bjørndal, 2016. p. 57 (our translation)). For some actors, the Polar Institute's consultation response was in fact the most up-to-date information available, and they

used it to support their arguments. The definitions came to play a key role in the ensuing debate over the map that was used in connection with the opening of the Barents Sea South-East.

The debate over the definitions took on a life of its own, independent of the oceanographers and geophysicists. Eventually, a parliamentary debate over the positioning of a physical phenomenon in a spatial dimension—a line on a map—was held. Examples from social media as well as mass media show how politicians actively took part in shaping the definition of the geographical positioning of the ice edge. An example from Twitter demonstrates how two opposing politicians raised explicit arguments for and against the definition of the ice edge (authors' translation).

Nikolai Astrup (member of the Storting (Conservative Party)): There is a difference between the ice edge and maximum sea ice extent over the last 30 years. Look at the map!

Heidi Sørensen (WWF Norway, and former member of the Storting for the Socialist Left Party): yes, you have assumed 30% probability of ice in April, whereas NPI has recommended max ice extent in April.

Astrup: we assumed exactly the same as you did

Astrup: note that there are time limitations on drilling; no activity between December and June.

This conversation on Twitter is interesting because it demonstrates the performativity of maps: The line on the map may well have a real-life consequence: petroleum exploration—or not. Furthermore, it illustrates how maps are co-produced visual discourses, appearing in a web of political issues, actors and sciences. In other words, it illustrates how formalised knowledge is constantly negotiated. Politicians do not perceive information and facts provided by experts as definitive, but actively discuss the premises for scientific inquiry: the proper definition of the ice edge. In doing so, they break with the separation ideal, and perform an iterative interaction with experts who are supposed to hold a neutral and objective position. Most interestingly, it gives insights into the ways in which politicians are not afraid to enter the scientific realm and promote strong opinions related to technical-scientific material. In fact, politicians contest the credibility of each other's interpretation of scientific material as part of a strategy to strengthen their own political statements. As will be demonstrated in the next section, politicians and scientists differ on this point.

The reluctant realists

In the discussion on the geographical positioning of the ice edge, few scientists participated in the debate over the geophysical definition of the ice edge. The Polar Institute made it crystal clear on several occasions that its mandate was to provide an objective description of the marginal ice zone—it was not supposed to get involved in deciding political priorities. To remain loyal to these ideals, it tried to position itself high up on both axes of separation and formalisation (ref. Figure 1), pointing to the 'hard' science they had produced and trying to shy away from the debate over how the science should be interpreted from a professional point of view. When the debate over defining the ice edge shifted to the Storting, The Polar Institute was asked to give answers on how the observations should be interpreted. The institute argued that they presented a professional interpretation and stressed that it was both important and possible to distinguish between professional and political dimensions of the map and the definition of the ice edge.

Navigating in this slush of water and politics proved challenging for the experts. The dynamic and three-dimensional ice edge is constantly moving which makes it difficult to prove what the ice edge is and where to draw it on a map. To do so might, paradoxically enough, be perceived as politically motivated. Nick Hughes, head of the Ice Service at the Norwegian Meteorological Institute, said in an interview when asked for a definition of the ice edge: 'This is a political question which I don't want to answer' (Rommetveit, 2017). It was impossible to prove where the ice edge was *really* located without simultaneously taking a stand on a political issue like oil exploration. However,

acknowledging the interpretative character of sea ice definition, weakens the perception of science and expert knowledge as neutral and objective, which was at stake for the Polar Institute. This may explain how mismatches between ideals of formalisation and separation and factual science-policy interaction, come into existence.

Proxy debates and democratic implications

As outlined in the above sections, a proxy debate ensued; various technical definitions of the ice edge were ostensibly discussed at the same time as future petroleum extraction in the Barents Sea was decided upon. Latour refers to pseudo-technical debates like these as 'politics by other means' (Latour, 1988, p. 229). Numerous examples exist of how in Norway heated debates on environmental policies are translated into scientific and methodological matters (Bay-Larsen, 2014; Bjørgo & Bay-Larsen, 2017; Dannevig & Dale, 2018). Methodological trade-offs are subject to explicit political deliberation until the phenomenon reaches an ontologically stable state (Steinberg & Kristoffersen, 2017); that is, until the definition of the ice edge becomes legitimate and agreed upon. Such proxy debates may therefore hinder transparent and inclusive public discussions over actual policy decisions at play. Narrowing down methodology and stable ontological states typically excludes actors and voices outside the scientific realm (Skorstad et al., 2018). This in turn may lead to a situation where power is exercised outside established democratic arenas and institutions. By masking *de facto* political debates as scientific disputes, actual political decisions may be rendered opaque and implicit.

On the other hand, the case presented in this article demonstrates how the maps enabled the media and political opponents to conduct an open debate on the development of oil resources in the Barents Sea. They provided those following the public debate with the possibility to see the intention behind the government's updated definition. The different maps were used as rhetorical devices in the debate, creating alternative perceptions of reality. They visualised different political arguments and clarified the political and economic interests at stake, as well as how those arguments rested on different scientific definitions. The new dataset represented an admission ticket to oil exploration further north and east in the Barents Sea, and was consequently rejected by the opponents of oil exploration in the Barents Sea South-East. From this perspective, it could be argued that maps may strengthen transparency and inclusion in complex environmental matters.

At the same time, prime minister Erna Solberg refused to admit the performativity and power embedded in the maps of the Barents Sea. In her speech at *Arctic Frontiers: Climate and Energy* in Tromsø on 20 January 2015, she declared: 'We have not moved the ice edge. It has moved by itself.' (NTB, 2015). This illustrates the recurring mismatch in science-based management regime: maps are portrayed as objective representations of the world, behind which politicians can hide while at the same time argue in favour of certain judgements and interpretations of the very same knowledge. The performativity and power of maps seem to be democratically illegitimate. Such a mismatch represents a possible threat to a science-based democratic model. If policymakers continuously refer to a sharp distinction that does not exist, the mismatch between what is said and what is done could harm both scientific credibility and political legitimacy. Rather than grand narratives about positivistic ontologies and representative maps, there is a need for a transparent public debate that trains the public, scientists and policymakers to understand science and policy as co-produced (Jasanoff, 2004). Maps may be valuable tools to reveal how heated policy debates take place within the scientific and political realms. Therefore, openly acknowledging the dynamic nature of maps, and the fact that they both define and are defined by the formation of opinions, may strengthen knowledge-based management for the future.

Conclusion

This article has shown how definitions and maps were co-produced through numerous negotiations, compromises between competing values and interests, observations and models of biological,

chemical and physical phenomena and, not least, through allocations of money and expertise to conduct the mapping. The case thus serves well to illustrate how maps are *performative*. Combining critical cartography with Sundqvist et al.'s (2015) framework produces at least two insights. First, combining these literatures reveals how maps and multiple ontologies of the ice edge—the temperate and dynamic boundaries between water and ice—are reflected in the blurred boundaries between science and policy. Neither can be separated across time and space. Second, the dimensions of separation and formalisation visualise how science and policy (always) interact to co-produce definitions and categories applied in spatial and knowledge-based management. It is within this interaction that power is negotiated and constituted. Openly acknowledging the performativity of maps and being explicit about the contingency and contextual character of scientific knowledge—not least about which judgements are made—may prevent proxy debates that may erode transparency in democratic decision-making. But this would also require scientists, including government scientists, to be ready to participate in open public debates.

Notes

1. https://arctic-sdi.org/
   https://kart.barentswatch.no/arealverktoy
   https://www.amap.no/
   https://www.caff.is/https://www.eppr.org/
   https://www.pame.is/.
2. https://www.miljodirektoratet.no/verktoy/naturbase/.
3. Act 29 November 1996 No. 72 relating to petroleum activities.
4. This article builds on and further develops a chapter in the book entitled *Interessekonflikter i forskning* (Conflicts of interest in research) by the same authors (Bay-Larsen, Hermansen and Bjørndal 2019). The core theoretical framework has been extended into current debates in cartography, and theoretical concepts like performativity are employed to cross-fertilise between strings of literature in cartography and the academic field of Science and Technology Studies (STS). Also new empirical material has been added (particularly on the public debate on the ice edge), resulting in a deeper and richer analysis.
5. Author's translation. Norwegian: I områdene ved iskanten og polarfronten skal det ikke igangsettes petroleumsvirksomhet nå. Spørsmålet om petroleumsvirksomhet ved iskanten og polarfronten vil bli vurdert på nytt i forbindelse med neste oppdatering av forvaltningsplanen for Barentshavet. Dette er ikke til hinder for at det kan drives petroleumsvirksomhet i hele Barentshavet sørøst.
6. The polar front, like the ice edge, is an area with a high level of biodiversity. The management plan from 2011 stated that petroleum activities would not be initiated by the polar front or the ice edge during the current parliamentary term (Bjørndal, 2016). However, in this paper, we have chosen to focus on the ice edge zone only, as this became the controversial topic.
7. The Norwegian Parliament.

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