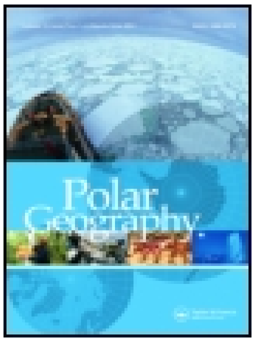

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Cruising the marginal ice zone: climate change and Arctic tourism

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ABSTRACT
The effects of climate change are leading to pronounced physical and ecological changes in the Arctic Marginal Ice Zone (MIZ). These are not only of concern for the research community but also for the tourism industry dependent on this unique marine ecosystem. Tourists increasingly become aware that the Arctic as we know it may disappear due to several environmental threats, and want to visit the region before it becomes irrevocably changed. However, 'last-chance tourism' in this region faces several challenges. The lack of infrastructure and appropriate search and rescue policies are examples of existing issues in such a remote location. Additionally, tourism itself may further amplify the physical and ecological changes in the Arctic region. In this article, we provide an interdisciplinary analysis of the links between the MIZ, climate change and the tourism industry. We also identify existing regulations and the need for new ones concerning operations in the MIZ and in the Arctic Ocean.

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Marginal ice zone; Arctic tourism; Arctic Ocean; cruise tourism; climate change

1. Introduction

In recent decades tourism has become a major human presence in the Arctic (Larsen & Fondahl, 2015), with seaborne tourism regarded as the fastest-growing segment of polar tourism (Bystrowska & Dawson, 2017; Dawson, Pizzolato, Howell, Copland, & Johnston, 2018; Johnston, Dawson, & Maher, 2017; Steinicke & Albrecht, 2012; Stonehouse & Snyder, 2010). Reduced sea ice cover results in extended sailing seasons, as well as improved accessibility to destinations that were once cut off, such as the Canadian Arctic (Stewart & Draper, 2008). However, changing ice conditions also threaten ice-related wildlife, the sighting of which is the very reason some tourists take part in these Arctic cruises (Lück, Maher, & Stewart, 2010). Indeed, Maher and Meade (2008) verified that seeing polar bears is the main

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reason for most tourists to visit national parks in the Canadian Arctic. As a result, tourists are rushing into the Arctic in what we may label as 'last chance tourism' (LCT) (Lemelin, Dawson, & Stewart, 2013a) in order to spot these iconic Arctic animals in their natural habitat. A major component of the Arctic marine ecosystem, where much of its wildlife is found, is the Marginal Ice Zone (MIZ), or the 'transition region from open ocean to pack ice' (Johannessen et al., 1987). Nevertheless, the MIZ is facing rapid physical changes, many of which will have implications for important biological processes, leading to ecosystem-wide effects (Derocher, Lunn, & Stirling, 2004). These changing conditions also have consequences for the safety and Search and Rescue (SAR) needs of tourism activities in the MIZ, which are essentially shipborne (Longrée & Hoog, 2014).

The MIZ has been widely studied from physical disciplines, specially in oceanography and marine biology. However, less attention has been given from a societal perspective, while strategic and economical interests become, increasingly and simultaneously, a focus point in the Arctic. The tourism industry is one example of a growing economic interest in this region, but challenges due to the dynamic nature of the MIZ must be considered. This article aims to conflate the physical changes of the MIZ with the tourism industry in order to bring to light emerging challenges, as well as potential future road maps.

The tourism industry closely depends on interactions with the MIZ, as far as safety allows it, since the further tourist vessels sail into the MIZ, the more likely they are to spot the sought-after wildlife. This article examines the implications of such proximity to the MIZ and its changing conditions, as well as the challenges that the tourism industry may face in the future. By summarizing the physical and biological properties of the MIZ, this paper will demonstrate how this particular zone of the Arctic Ocean and tourism activities interact, in terms of biodiversity, safety and SAR issues. At the time of writing, research regarding Arctic tourism refers predominantly to Canadian waters and includes issues of melting sea ice (Pizzolato, Howell, Derksen, Dawson, & Copland, 2014; Stewart et al., 2013), social and economic impact (Johnston, Johnston, Stewart, Dawson, & Lemelin, 2012; Stewart, Dawson, & Johnston, 2015), as well as governance issues (Dawson, Johnston, & Stewart, 2014; Pashkevich, Dawson, & Stewart, 2015). While the management of cruise tourism in Svalbard has also been studied in the past (Bets, Lamers, & van Tatenhove, 2017; Hagen, Vistad, Eide, Flyen, & Fangel, 2012), apart from sea ice, the role of climate change has been an under-analyzed topic and the impact of a changing MIZ on tourism has not gained much scientific interest so far. Similarly, the political and regulatory implications of operating in the MIZ are also in need of attention. Access to and possible exploitation of resources as well as maritime activities, both civil and military, are regarded as drivers for change in the Arctic. Since 2001, the Arctic coastal states have submitted their respective, and sometimes overlapping, claims for extended continental shelves in line with article 76 in the United Nations Convention on the Law of the Sea (UNCLOS) (United Nations, 1982). This demonstrates the need for and importance of continued development and implementation of sustainable governance and regulatory frameworks for the Arctic region. Hence, this article aims to bridge the interdisciplinary gap connecting the field of tourism studies to the implications and challenges of climate change.

2. Expanding Arctic cruise tourism

The MIZ presents many additional navigational risks when compared to open water sections of the Arctic Ocean. As such, several industries operating in the Arctic Ocean do not, or cannot, closely interact with it. For example, sea ice represents a danger for shipping (Buixadé Farré et al., 2014; Østreng et al., 2013), as defined in the Polar Code (MEPC, 2015), and therefore most ships tend to operate in the outskirts of the MIZ, to reduce the likelihood of contact with sea ice. Nonetheless, exceptions exist, such as cruise ships, research icebreakers or naval ships that navigate within the MIZ.

The fishing industry will also avoid a presence in the MIZ (Niiranen et al., 2018), as well as oil and gas activities generally benefiting from operating in open waters (Harsem, Eide, & Heen, 2011). Therefore, the MIZ can be said to serve as an area of strategic significance economically. Additionally, this area has served for military purposes, since the late 1970s, an example being the concealment of submarines in the ambient noise produced in the MIZ, where the constant cracking of moving ice overshadows the noise generated by any submarine, thus hiding them from passive sonar detection (Vidas, Ostreng, & Polhøgda, 1999). However, unlike submarines, which do not interact directly with the surface of the MIZ, cruise vessels face many more risks. Following this perspective, the tourism industry is unique in its dependence on navigating deeper into the MIZ, differing from that of most other human activities in this region.

Tourism has been present in the Arctic for over two centuries (Stonehouse & Snyder, 2010), with the first tourists consisting predominantly of wealthy and curious independent adventurers (Snyder, 2007), as well as explorers and scientists (Hall & Johnston, 1995). Nowadays, Arctic tourism, especially the cruising tourism industry, is rapidly growing (Larsen & Fondahl, 2015). Indeed, Stonehouse and Snyder (2010, p. 30) stated that 'the cruise ship industry is the single largest provider of mass tourism in the Arctic'. The breakthrough in Arctic cruising coincided with the collapse of the Soviet Union, after which Russian ice-breakers entered the commercial market, supporting Arctic tourism operations (Stewart & Draper, 2008). More so, these circumstances enabled cruises to the North Pole, organized through Russian waters or supported traverses through Northeastern passages.

In the Northwest Passage, cruise tourism started to attract more interest after the successful voyage by the *MS Explorer* in 1984 (Johnston, Johnston, Dawson, & Stewart, 2012; Stewart & Draper, 2008). Nowadays, most of the cruises organized in the High Arctic, both large conventional cruises and those with smaller expedition vessels, visit the archipelago of Svalbard (Bystrowska & Dawson, 2017). Significantly less cruise traffic occurs in Greenland, followed by the Canadian Arctic, where the growth of private pleasure crafts has recently dominated the commercial cruises, as shown in the recent Arctic Council's report on 'Adaptation Actions for a Changing Arctic: Perspectives from the Baffin Bay/Davis Strait Region' (AMAP, 2018). In the Russian Arctic, cruises are relatively rare, but there is also a lack of consistent statistical data to assess tourism-related numbers precisely (Hall & Saarinen, 2010b). Nevertheless, the growing popularity of Arctic cruise tourism can also be shown with the increasing number of available cruises, and the growing size of the ships sailing in Arctic waters, as well as the construction of new tour ships specifically designed for polar waters. Indeed, the cruise operator *Hurtigruten* has launched the construction of two new ships designed for Arctic waters (*MS Fridtjof Nansen* and *MS Roald Amundsen*), both of which should join their fleet by 2019. Additionally, the French cruise operator *Ponant* has also revealed their plans to build the first luxury icebreaker cruise ship, to be ready to sail in 2021 (Ponant, 2018). Furthermore, the *Crystal Serenity* was the first cruise ship with more than 1500 passengers and crew members sailing the Northwest Passage during the summer of 2016 (Revkin, 2016), showing that tourist's interest in Arctic cruise is indeed increasing. Other indicators can show the growth of Arctic cruises, such as the number of passengers taking part in these cruises, the number of kilometers sailed by the total amount of cruise ships in Arctic waters per year or the revenue generated by the cruising industry to local communities. However, due to regional differences leading to problems of consistent and comparable data, it seems rather complicated to demonstrate the growth from a global perspective. Despite this obstacle, regional perspectives still illustrate this expansion. According to the Association of Arctic Expedition Cruise Operators (AECO) (AECO, 2018), the number of cruise passengers around Svalbard increased from around 39,000 in 2008 to over 63,000 in 2017 (Numbers kindly provided by AECO on request). In the same period, the numbers on Greenland remained rather stable, ranging between 20,000 and 30,000 per year. In the rest of the High Arctic, only few cruises occur, but the numbers are also increasing; for example, in the Northwest passage from 124 passengers in 2008 to 1199 in 2017. Overall, cruise passengers statistics from AECO show a growth of about 57% from 67,752 in 2008 to 98,238 in 2017 (see Bystrowska and Dawson (2017) for complementary data). In addition, the total amount of sailed kilometers by passenger ships in the waters of the Canadian archipelago grew from 3496 in 1990 to 68,384 in 2013 (Dawson et al., 2017, 2018). In Alaska, the analysis of commercial passengers vessels revenues shared with local municipalities, cities or boroughs indicates a global growth from US $744,580 in 2007 to US $15,750,925 in 2016 (Department of Commerce, 2017). According to Maher (2017, p. 218), 'by all accounts, the future involving larger cruise ships, seeking passage through key routes is upon us'. It is clear that, with expanding ship fleets and increasing vessel capacity, Arctic cruise tourism has a competitive and growing market. In parallel to this development, the Arctic cruise industry has also been attracting growing scientific interests, and potential concern.

With Arctic cruises starting to penetrate further into the MIZ, there comes the risk of increased ecological impact. The MIZ is an area of high productivity, and as a result, high biodiversity in comparison to other regions of the Arctic ocean. Many fish, marine mammals and seabirds thrive in the MIZ and gather at the ice edge (Reeves et al., 2014). There is increasing concern about the potential impact of Arctic tourism on the wildlife found in the MIZ. Additionally, environmental consequences of accidents in the Arctic are likely to be more serious than in warmer waters. For example, contaminants can be transported by sea ice from one Exclusive Economic Zone (EEZ) to another, therefore making contamination in the Arctic a trans-national issue (Newton, Pfirman, Tremblay, & DeRepentigny, 2017). Oil and other hazardous materials are also more difficult to remove in icy conditions, and the natural cleaning process through the dissolving, decomposition or evaporation of the substances are significantly impeded by low water and air temperatures (Liu, Kirk, & Henriksen, 2017).

While the retreat of the pack ice, and thus of the MIZ, can be seen as a major opportunity for the cruise ship industry (Johnston, 2006) and local communities, it also presents challenges. On one hand, as the sea ice retreats, the cruising season becomes longer, which allows cruise liners to plan trips earlier and later in the season. Not only this, but the retreat of the pack ice provides better access to remote locations that can embrace growing tourism as the summer season lengthens (Hassol, 2004; Lamers, Duske, & van Bets, 2018). In 2006, several new communities were included in shore visits during the cruise of the *Explorer* in the Canadian Arctic, such as 'Arctic Bay, Grise Fjord, Pond Inlet, Kimmirut, Cape Dorset, Pangnirtung, Clyde River, and Iqualuit' (Stewart & Draper, 2008, p. 225). According to Stewart, Howell, Draper, Yackel, and Tivy (2007, p. 370-371), cruise tourism in the Arctic can be considered as 'one of the few positive outcomes associated to climate change in the Arctic'. Conversely, there is still a need for caution. Climate change in the MIZ is endangering wildlife, and as a result may impact the interest of tourists taking part of these cruises. Tour operators will have to venture into increasingly remote areas in order to seek out the rare, sought-after wildlife. Such remote conditions may lead to logistical complications, arising from the lack of infrastructures in these regions, as well as decreased SAR capabilities.

3. Last-chance tourism in a changing MIZ

3.1. Last-chance phenomena

LCT is the concept by which tourists seek out regions and ecosystems under rapid change, such as the MIZ, in order to experience them in their classical setting before they are potentially, irrevocably changed (Hall & Saarinen, 2010a; Lemelin, Dawson, & Stewart, 2013b; Lemelin, Dawson, Stewart, Maher, & Lueck, 2010). It is a global phenomena that not only concerns the Poles, but other similar threatened ecosystems as well, such as the Great Barrier Reef (Coghlan, 2013) and alpine regions (Steiger, Dawson, & Stötter, 2013). Recently, LCT has been enhanced by media and travel magazines which have widely contributed to the success of this trend, with titles such as '25 places you should visit before they disappear forever' (Schmalbruch, 2017) or ' Six fascinating places you need to see before it's too late' (Gebibki, 2017) (see also Eijgelaar, Thaper, & Peeters, 2010; Lemelin et al., 2013a).

In the case of the Arctic, the polar bear has not only become an infamous symbol of climate change, but also a major icon for LCT (Dawson et al., 2011). Polar bears are thus at the forefront of tourists' and tourism entrepreneurs' interests. Indeed, according to Kelly (2008), one of the main reasons for tourists to take part in Arctic tourism was in an attempt to see polar bears (see also Dawson et al., 2011; Eijgelaar et al., 2010). More so, many tourism entrepreneurs, and especially cruise liners, also use polar bears in their advertisement, given its aforementioned connotations, as many Arctic cruises concern wildlife safaris.

For example, *Hurtigruten*, *Ponant* and *Quark Expeditions* propose cruises called 'Circumnavigating Svalbard – In the Realm of the Polar Bear', 'Discovery of the King of the Arctic', referring to polar bears, and 'Spitsbergen Photography: In Search of Polar Bears', in their catalogues respectively. Even in academia, polar bears have been drawing great interest in tourism studies (Dawson et al., 2011; Dawson, Stewart, Lemelin, & Scott, 2010; Lemelin et al., 2010; Stewart, Dawson, & Lemelin, 2013). Despite the polar bear being the poster child for the effect of climate change on the Arctic, the changing conditions of the MIZ affect the entire ecosystem, including the less-iconic fauna. However, many of these affected species are of less interest to tourists. Dawson et al. (2011, p. 254) noted that populations of cod are among the most threatened species living in the Arctic, but 'no cod viewing industry has emerged nor is it likely to in the near future.'

In the Arctic, there is a range of both terrestrial and marine last chance wildlife tourism. Churchill, Canada, has seized the opportunity of the polar bear viewing industry on land, and is known today as 'the polar bear capital of the world' (Dawson et al., 2010, p. 89). At sea, much of the iconic Arctic wildlife can be spotted within the MIZ, contributing to tourists' interest to take part in cruises. Consequently, the MIZ has become a tourist destination, based on the expectations of viewing ice-associated wildlife (Stewart et al., 2007). In other words, as noted by Dawson et al. (2011, p. 250), 'the emphasis is not on 'firsts' but rather on 'lasts'.' That is, the last one ' to witness the tumble of the final glacier in Antarctica or Greenland; to observe the last breath of an emaciated polar bear in Churchill, Canada.'

(Lemelin et al., 2013b, p. 3). However, Dawson et al. (2011) and Lemelin et al. (2013b) have raised the question of ethics in LCT in the tourism practices of our modern Western society (see also Smith, 2013), but this goes beyond the scope of this article.

3.2. Oceanographic changes in the MIZ

The MIZ can be simply defined as the transition region between the open ocean and the inner ice pack. However, it is a highly dynamic zone, where the atmosphere, the ocean and the sea ice interact. Therefore, this first definition seems too elementary in regards of the complexity of that region. Specific parameters have been used to delimit the MIZ including sea ice concentrations and wave penetration. Thus the MIZ could be defined as areas of sea ice concentration between 15% and 80% (Strong, 2012), or as the region corresponding to the distance in which waves can penetrate into the ice pack before they become attenuated (Dumont, Kohout, & Bertino, 2011; Squire, Dugan, Wadhams, Rottier, & Liu, 1995; Wadhams, 1986). As a result, the MIZ cannot be delimited by a simple line on a map, as it covers a much broader area. Indeed, its width varies in time and space, typically from 50 to 300 km (Dumont et al., 2011; Strong, 2012), depending on the season of the year.

The MIZ is a hazardous zone for navigation due to the unpredictability in width, sea ice concentration, thickness and fast-changing ice movements. Not only this, but the MIZ is highly affected by climate changes (Shephard et al., 2016). Indeed, the retreating sea ice cover is one of the most visible manifestations of on-going climate change in the Arctic (Johannessen, 2008; Johannessen et al., 2004; Serreze, Holland, & Stroeve, 2007; Wang & Overland, 2012). Using satellite data, the observed changes during the period from 1979 to 2016 include a 35% reduction in Arctic summer sea ice extent, a 15% reduction in winter and an annual reduction of 10%. In addition, significant ice thinning (Kwok & Rothrock, 2009), transitioning from multi-year to first-year ice (Galley et al., 2016; Johannessen, Shalina, & Miles, 1999; Maslanik, Stroeve, Fowler, & Emery, 2011; Polyakov, Walsh, & Kwok, 2012), and extended melting seasons (Stroeve, Markus, Boisvert, Miller, & Barrett, 2014), contribute to changing the sea ice system. The ice volume has also been reduced by 70% during summer months and by 20% during winter months (Zhang, Rothrock, & Steele, 2017). Future projections show that the Arctic summer sea ice cover will continue to decline under a warming climate, which could lead to ice-free conditions in the Arctic Ocean by the middle of the century (Notz & Stroeve, 2016; Stroeve, Holland, Meier, Scambos, & Serreze, 2007; Wang & Overland, 2012). These trends towards younger and thinner ice have the effect of shifting the poleward edge of the MIZ northward in the summer, and shifting the equatorward edge of the MIZ northward in the winter (Strong & Rigor, 2013). Observation made over the period between 1979 and 2011 show that the width of the MIZ widened by 13 km per decade in the summer; and narrowed by 4 km per decade in the winter (Strong & Rigor, 2013).

The pronounced impact of climate change on the MIZ, and the Arctic in general, is due to an effect called Arctic Amplification (AA). While AA occurs during all seasons, it is most pronounced throughout autumn and winter (Cohen et al., 2014). Changes in the ice-albedo effect (Stroeve et al., 2012) as well as changes in the poleward transport of heat and moisture (Screen, Deser, & Simmonds, 2012) are amongst the main drivers for AA. These processes have induced a massive warming of the Arctic, which has resulted in the dramatic loss of sea ice as described above (Screen & Simmonds, 2010). The reduction in sea ice, particularly in the MIZ, might result in a higher mobility and thus unpredictability of ice floes and ice-covered areas in the future (Manucharyan & Thompson, 2017).

At low sea ice concentration, ice floes are close to a freedrift regime driven by forcing from winds and oceanic currents. The characteristics of the MIZ can therefore rapidly change under the effects of waves, tides and storms penetrating the Arctic. The drastic changes the MIZ is undergoing will undoubtedly affect the wide range of species that inhabit it, as discussed below.

3.3. Biological changes in the MIZ

The intense seasonal algal and phytoplankton blooms of the MIZ are due to the unique oceanographic features occurring there. This includes nutrient-rich upwelling at the ice edge and water column stratification due to spring ice melt, maintaining phytoplankton in the well-lit photic zone (Leu, Søreide, Hessen, Falk-Petersen, & Berge, 2011; Sigler et al., 2016). These physical characteristics make the MIZ an area of important high latitude primary productivity, supporting a multitude of higher trophic levels, leading it to be an area of pronounced ecological significance (Engelsen, Hegseth, Hop, Hansen, & Falk-Petersen, 2002).

Indeed, the MIZ is an important habitat for the 11 Arctic mammal species dependant on sea ice (e.g. seals, cetaceans, walruses or polar bears) (Laidre et al., 2015), as well as numerous seabird species (Anker-Nilssen, 2000; Haug & Nilssen, 1994; Whg, 1995). For example, many seal species use the patchy ice floes of the MIZ to evade predators. More so, the MIZ is also a key environment in the reproduction of several seal species, including ringed seals and bearded seals, which use the sea ice to breed and birth their young (Kovacs, Lydersen, Overland, & Moore, 2011). Iconic Arctic cetaceans, such as belugas and narwhals, also use the MIZ as a plentiful source of their ice-associated prey, and to potentially shelter from the strong wave action caused by storms (Kovacs et al., 2011; Vacquié-Garcia et al., 2017). Not least of the Arctic charismatic megafauna, polar bears use the MIZ as an important hunting ground, with their primary prey being ringed seals, and as a transportation corridor to travel to the dense pack ice (Kovacs et al., 2011; Lone, Merkel, Lydersen, Kovacs, & Aars, 2017). Furthermore, many seabirds, both endemic and migratory, use the MIZ as a key feeding ground, taking advantage of the abundance of lipid-rich zooplankton which are fed by the intense phytoplankton blooms (Divoky, Douglas, & Stenhouse, 2016; Hunt, 1991; Mehlum & Gabrielsen, 1993). However, this diverse and productive ecosystem is seriously threatened by the physical effects of climate change (Falk-Petersen, Pavlov, Timofeev, & Sargent, 2007; Slagstad, Ellingsen, & Wassmann, 2011; Vaughan et al., 2013; Wassmann & Reigstad, 2011).

The MIZ is experiencing thinner ice and increasingly open water. Such changes will have a myriad of effects on the activities of the aforementioned Arctic wildlife, such as a lack of hunting ground for polar bears. Not only this, but the sea ice changes of the MIZ have the potential to disrupt the unique dually pulsed primary production, the early spring ice algal, followed by the later phytoplankton, bloom of this ecosystem (Barber et al., 2015). Many zooplankton species depend on this dual production for reproduction, using the ice algal as a food source for egg production, which allows their offspring to then utilize the later phytoplankton bloom when they hatch (Søreide, Leu, Berge, Graeve, & Falk-Petersen, 2010). Disruption in the primary production could cause a trophic mismatch, with zooplankton reproduction cycles becoming unaligned with primary production (Jin & Varpe, 2012).

This may lead to negative effects on zooplankton populations, and more so a reduction of important lipid-based energy input into the marine food web, affecting populations of the aforementioned higher trophic levels (Leu et al., 2011; Sigler et al., 2016).

In the context of Arctic tourism, the charismatic megafauna that occupy the MIZ, either temporarily or year-round, are a key factor. Indeed, 'Arctic Safaris' are directly relying on the presence of these animals. Thus, the physical changes in the MIZ not only threaten the wide range of Arctic fauna found there but pose serious consequences for the industries dependent on the biodiversity of its ecosystem.

4. Navigation in the MIZ

Cruise vessels tend to navigate in the MIZ, where ice floes and icebergs are readily present, which according to the Marine Environment Protection Committee (MEPC) can be considered one of the most dangerous navigational environments a ship may encounter (MEPC, 2015). Considering the size of cruise ships, carrying potentially thousands of people, both passengers and crew, it is important that adequate infrastructures for emergency response are established for SAR. However, there is currently an unequal distribution of such infrastructures in the high Arctic. As such, there are still vast remote areas that lack appropriate SAR installations, as well as minimal bathymetric data for modern charts and skilled personnel to navigate through ice infested waters (MarSafe, 2011). These factors are a legitimate concern regarding the intent of the cruise-ship industry on expanding its operations to Arctic regions.

4.1. Search and rescue (SAR)

The decline of Arctic sea ice will directly impact the tourism cruising industry in terms of opportunities and challenges. As noted by Johnston (2006, p. 48), 'the decline in sea ice will provide more open water for navigation', but 'there might be additional hazards to navigation through an increase in iceberg calving and through the instability of what pack ice remains'. As a consequence, these particular waters of the MIZ will become more unpredictable in terms of sea ice variability, revealing the challenges for SAR and related infrastructures.

To ensure safe and adequate planning of human activities in the Arctic and the MIZ, sea ice forecasts are required on a range of timescales. Such forecasts should vary from short-range and sub-seasonal forecasts for short-term decision making (including navigation and SAR operations), to seasonal and interannual forecasts for long-term planning. Different sources of potential predictability for sea ice have been investigated, such as persistence or advection of sea ice anomalies, or interaction of sea ice with the atmosphere and the ocean (Guemas et al., 2016). Despite significant research efforts in this direction, significant challenges remain in the predictions of some key sea ice parameters. For instance, since the proportion of seasonal sea ice has overtaken multi-year ice in the Arctic Ocean, existing prediction methods have become more vulnerable to deviating weather conditions (Hamilton & Stroeve, 2016). Current prediction methods have potential uses for decision-making, but their application for policy and planning still faces several issues (Stephenson & Pincus, 2017).

The Arctic Marine Shipping Assessment report (AMSA) produced by the Arctic Council (Arctic Council, 2009) revealed that the SAR infrastructure in the Arctic is limited, although it varies between different regions. It further indicated that, while some icebreakers and seasonal patrol vessels can be used for SAR when in the vicinity of an incident, critical response assets are lacking, such as long distance, heavy-lift capacity helicopters. Moreover, it states that the usefulness of some assets is subject to existing weather and other operating conditions.

Similar initiatives, such as The MarSafe High North project (MarSafe, 2011) and ACCESS (Longrée & Hoog, 2014), assessed environmental challenges and escape, and evacuation and rescue, respectively, within maritime operations in the High North. Their general conclusion was that response systems and available infrastructures may not be sufficient for handling incidents involving a large number of people in remote locations. These conclusions are particularly important in light of the receding MIZ and increasing tourism in harsh Arctic waters. Additionally, the availability of new shipping areas with poorly known ocean bathymetry results in added uncertainty and risk to operations due to potential grounding.

The Arctic Search and Rescue Agreement (Arctic Council, 2011) was the first legally binding agreement among the member states of the Arctic Council. More recently, the Polar Code, which has been adopted by the International Maritime Organisation (IMO) and entered into force on the 1^{st} of January 2017, intends to reduce the risk of maritime accidents in the Arctic by imposing strict SAR requirements. However, despite the clear roles and responsibilities in these agreements, there is a need for both public and private stakeholders to collaborate and thoroughly implement the necessary SAR mechanisms and tackle today's needs and insufficiencies. In fact, the Arctic Council's final and latest report on implemented AMSA recommendations (Arctic Council, 2017a) confirms significant achievements and advancements, but also highlights the importance of collaboration in order to address remaining and emerging issues.

4.2. Infrastructure for communication in the MIZ

Infrastructures in the MIZ, and other areas affected by the reduction of sea ice and improved navigability, will need to cope with the increasing demand of human activities, such as tourism. This includes not only scaling infrastructures, but also the use of different new resources, such as improved SAR vessels and communication links and coverage. The IMO provides guidelines for activities in polar environments, referring to several additional demands imposed on vessels such as the support of better navigation mechanisms, communication systems and improved life-saving equipment (Jensen, 2016).

Concerning the MIZ, as well as other regions at high latitudes, the Norwegian Ministry of Climate and Environment (NMCE) considers that challenges exist for navigation, and limitations in telecommunications and coverage require special attention, since they are crucial for safety and response to unexpected incidents (NMCE, 2016). The design and implementation of new maritime digital communication systems for Polar waters is currently lacking (MEPC, 2015), with Iridium being the only globally available service. However, Iridium and other Geostationary Satellite solutions currently only offer limited bandwidth capacity at a very high economic cost (Arctic Council, 2017b; Palma & Birkeland, 2018), not being suitable for nautical operations (MarSafe, 2011), such as cruise tourism.

Limited communication potential is a major issue regarding the safety of cruise tourism. In the Arctic, currently existing communication systems rely mostly on Very High Frequency (VHF) for short distances (within line of sight), which are limited in bandwidth and normally used only for voice communication. High and medium frequency radios are existing alternatives to coverage issues, but are mainly used for emergency solutions, due to their limited bandwidth. Other solutions for supporting data transmission can be found in close-to-shore stations and other infrastructures, such as the Automatic Identification System or VHF, but these are limited in Arctic regions and the MIZ. Moreover, typical satellite services based on Geostationary Earth Orbit are limited by the instabilities in signal quality, which are not considered as reliable in areas above 75° North (MarSafe, 2011).

In addition to the challenges in communication and connectivity, the MarSafe Project (MarSafe, 2011) has also identified issues with Dynamic Positioning and the coverage offered by Differential Global Positioning. These systems, among others requiring high-availability of communication, are crucial for ship-based tourism and other maritime operations. In fact, Information and Communication Technologies play an important role in the sustainable management of vulnerable, nature-based touristic sites, such as those in the Arctic. In this sense, conducted maritime operations are typically supported by different sources of data, including scientific data collected by tourism operators in-situ. An example of ongoing efforts to improve knowledge in Arctic seas are initiatives such as the Polar Prediction Project (PPP) (PPP, 2018), its Societal and Economic Research and Applications (SERA) subcommittee (PPP-SERA, 2018), and the SALIENSEAS project (SALIENSEAS, 2018), which aim at enhancing existing information on the polar regions by promoting and coordinating research data gathering and management, as well user-engagement and education activities, building on participatory tools suitable for end-users and stakeholders both in the private and public sectors. The development of infrastructures and communication technologies in the MIZ presents a unique opportunity not only for Arctic communities and stakeholders but also to the protection of the MIZ. Ultimately, better models and verification tools for understanding the MIZ can be achieved, complementing remote-sensing data sets and benefiting both tourism and local communities.

5. Current regulatory frameworks

Throughout this paper, we have indicated that the MIZ, an area of particular importance for biodiversity and ecosystem services, is under great pressure of ever-increasing tourism. This section looks deeper into the legal perspectives of the MIZ. While existing frameworks are fundamental for maintaining the MIZ's characteristics, we argue that they should be further developed in order to fill existing gaps in terms of protecting such characteristics, as well as cruise ships operating within the MIZ.

5.1. Regulating a dynamic zone of ice

Regulating and defining a jurisdictional area with a dynamic geographical extension like the MIZ is a challenge. In the summer, the MIZ will be mostly present in high latitudes due to the reduction of the sea ice, whereas in the winter, it will be stretched out towards the land, possibly controlled by the coastal states of the Arctic.

Under the international maritime law, the coastal states have been provided with various jurisdictional competencies regarding maritime activities depending on the concerned zone. Therefore it seems necessary to briefly go through these three delimited sea zones, in order to understand the coastal states' regulatory power in regards of the MIZ.

Firstly, the territorial seas are defined by UNCLOS *Article 3* as the seas extending up to 22.2 km to (12 M). States can exercise complete legislative and enforcement jurisdiction (full sovereignty) over all matters and all people in an exclusive manner (Tanaka, 2012). If the MIZ extends to the territorial seas, the coastal state has full control over the activities conducted in the MIZ, and this includes cruise vessels. They can also adopt environmental protection laws and enforce them freely.

Secondly, the continuous zone is defined under the *Article 33* of UNCLOS as an area that expands up to 44.4 km (24 M) from the baselines, which the breadth of the territorial sea is measured. In opposition with territorial seas, coastal states' powers are quite limited in that second zone. For example, countries do not have the power to prevent or punish any activities conducted in by a third party. Nevertheless, countries' powers to prevent or punish are limited to infringements of their own laws and regulations related to customs and fiscal issues, immigration; sanitary matters. Under the sanitation criteria, however, the coastal state would have certain rights related to prevention and punishment of cruise vessels navigating in the MIZ. This criterion would allow state authorities to inspect incriminated vessels and punish them on non-compliance basis.

Thirdly, the EEZ broadens up to 370 km (200 M) of the territorial baseline of a state (UNCLOS, *Article 55*). *Article 56* of UNCLOS precises that coastal states have certain rights concerning the conservation, management and the exploitation of natural resources, as well as various other activities regarding exploration and economic purposes, such as the production of energy from water, currents, and winds.

In summary, when cruising the MIZ, the applicable regulation is dependent on geographical zones defined independently of the MIZ. It is hence a question of where the vessel is in relation to these zones, rather than if the vessel is inside or outside the MIZ. Knowing the particularities and needs of the MIZ as discussed in this paper, this may be considered as a gap in legislation.

5.2. The United Nations convention on the law of the sea

The fundamental and major regulatory framework set for the international relations in oceans is the 1982 UNCLOS (United Nations, 1982). It is a convention which all Arctic coastal states, except the United States, are party to. It provides the legal framework for the uses of the oceans by covering issues such as navigation, boundary delimitation, environmental protection, marine scientific research, living and non-living marine resources, transfer of technology and peaceful settlement of disputes.

The five Arctic coastal states have specifically emphasized that the UNCLOS 'provides a solid foundation for responsible management by the five coastal states and other users of this Ocean through national implementation and application of relevant provisions' (Arctic Five, 2008). Still, since the Arctic Ocean has only recently been recognized as an accessible body of water, the UNCLOS does not address the aforementioned MIZ issues directly. One exception to this is *Article 234* of UNCLOS, where the Arctic coastal states are provided with additional legislative and enforcement jurisdiction over international shipping in ice-covered waters, for vessel-source pollution purposes. The fact that this article is not applicable to any other marine region makes this provision an exceptional rule, a *lex specialis*. Currently, two Arctic states, namely the Russian Federation and Canada, have used *Article 234* to strengthen the regulatory measures for marine environmental protection in the Arctic Ocean. However, none of them have specifically addressed navigation in the MIZ.

5.3. The polar code

The IMO's adoption of the International Code for Ships Operating in Polar Waters (the Polar Code) is a set of amendments to two existing IMO safety and environmental protection instruments: the International Convention for the Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution from Ships (MARPOL). These amendments aim to adapt and enhance ship systems for operations in both Arctic and Antarctic waters (MEPC, 2015). Another key element being addressed is the experience and training of ship's officers and crew, especially ice navigators on voyages in ice-covered polar waters, with the latest amendment dating from July 2018 (IMO, 1978, 2018).

The Polar Code is intended to cover the full range of shipping-related matters relevant to navigation in polar waters. This includes ship design, construction and equipment, operational and training concerns, SAR, and the protection of the unique environment and ecosystems of the polar regions.

In its current form, the Polar Code does not directly address the MIZ, however, potential modifications can be added in the future, although such a process may be lengthy. For example, 25 years were necessary to finalize the Polar Code, which is not a stand-alone instrument. Indeed, the Polar Code refers to an amendment to already existing conventions such as the SOLAS, MARPOL, and STCW. Under tacit acceptance procedure (Hathaway, Sanghvi, & Solow, 2011), any provision related to polar waters can be later inserted in one of these three conventions and included in the Polar Code.

5.4. A possible road map

As seen above, the Polar Code and the UNCLOS do not address the MIZ specifically. Hence, with the current upwards trending in Arctic tourism, additional measures should be made to ensure best practices in the MIZ for cruise ships and their passengers. Such measures should regard health and safety issues as well as take a precautionary approach to environmental impacts from cruise activities (Molenaar, Koivurova, Tedsen, Reid, & Hossain, 2014).

A top-down approach would be to fill the above-identified legislation gaps. In this sense, the Arctic Council has evolved throughout the years as an intergovernmental forum and proved itself to be instrumental in shaping the governing structure of the Arctic. Under the Council's auspice and through the contribution of its working groups, the Arctic states have adopted a number of non-binding and regional legal instruments such as the Agreement on Cooperation on Aeronautical and Marine Search and Rescue in the Arctic, the Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic, and lastly, the Agreement on Enhancing International Arctic Scientific Cooperation.

The Arctic Council can be a viable option in creating a legal instrument to protect and regulate the MIZ. As a matter of fact, the Protection of the Arctic Marine Environment (PAME) working group has been developing an area-based management system under the name of the marine protected areas network (Arctic Council, 2015b). Moreover, it is possible to include the MIZ as a sensitive area which needs recognition and protection, and create a regional agreement such as the ones listed above. However, it is important to consider that the UNCLOS articulates unequivocal freedoms allowing all states to use Areas Beyond the National Jurisdiction (ABNJ) (Kwiatkowska, Molenaar, Elferink, & Soons, 1998). Therefore, unless legal compliance by non-Arctic states is secured, the effectiveness of such a regime will also be questionable (Hossain, 2014).

The United Nations, through the IMO, have two potential legal instruments that can be employed for the protection of the MIZ. One is the Polar Code and the other is the ability to designate the MIZ as a Particularly Sensitive Sea Area (PSSA).

The designation of a PSSA provides special protection to ecologically important and vulnerable areas (Arctic Council, 2015a). The MIZ can be designated as a PSSA if the Arctic states mutually agree on this. However, since it only serves as a guideline it depends on the voluntary compliance of its signatory states. It is also important to note that, to date, the IMO has not designated any PSSAs in ABJN (Hossain, 2014). Therefore, if offered and accepted, such a PSSA would be the first beyond the ABNJ, and in the Arctic Ocean in general.

A bottom-up approach would be to accompany legislation and guidelines by certification standards and labeling to be used by the singular cruise ship companies. Today, several are standards available, such as the Polar Ship Certificate or MARPOL certificates (MEPC, 2015). Considering that cruise ships offers a service to their clients, a cruise ship travel, the same reasoning of labeling could be applied to the service itself.

The development and implementation of legislative instruments and guidelines are lengthy processes, whereas certificates and labels can be developed and implemented within a shorter lead time. Furthermore, such labels can allow more stringent criteria than it is possible to obtain in international, or even national regulations. This is for example the case for the Nordic Ecolabel, the Swan, where the label's criteria on emissions from wood combustion are more stringent than what is the case in the Norwegian, Swedish and Danish national regulations (ACAP, 2014).

The impact of voluntary guidelines, certification and label schemes could be increased if they appeal to and become a part of the corporate social responsibility standards of the cruise ship companies. Information campaigns targeted at increased customer awareness could drive a change indirectly, by creating a demand for sustainable cruises. The hypothesis is that tourists want to see the Arctic without negatively impact it and therefore a bottom-up approach involving the companies and customers should be considered.

6. Conclusion

Tourism in the Arctic, especially in the MIZ, is highly dependant on its unique environment, with development of nature-based tourist activities, such as wildlife safaris and natural sightseeing tours. In other words, the tourism industry is highly susceptible to the current effects of climate change in the Arctic, and the changes this is causing in the MIZ. This article has explored the relation between tourism cruises and climate change impacts, on both the physical and biological parameters of the MIZ. Thus, it acknowledges that effects on sensitive oceanographic features not only threatens Arctic biodiversity but also the cruising tourism industry in that region. As a result, cruise liners will have to venture deeper in the MIZ and into potentially more remote locations, leading to safety and navigational concerns. However, despite the various threats for navigation in a changing MIZ, the study also acknowledges the lack of international measures directly concerning it.

The Polar Code and the UNCLOS *Article 234* do not provide protection for the MIZ, hence a road map should be created to address the issue. For example, if a regional agreement could be reached, the IMO's PSSA and the Arctic Council's area-based management system could be two alternatives for the legal protection of the MIZ. However, these legal instruments will not have guarantee necessary enforcement and therefore can not offer a permanent solution. Currently, the shortest route to a solution would be for the Arctic states to push for the mandatory application of the PSSA, while applying for the MIZ to be included in its current guideline form. Certification and labeling standards appealing to singular cruise ship companies and their customers could support a swift implementation of best practices and should be considered as a supplement to legal instruments and guidelines. In the long run, an international legal regime that provides for cross-sector marine protected areas would be the ultimate solution for the MIZ. This would require thinking beyond a single commercial activity or industry, protecting the Arctic through legal instruments, to develop a long term solution.

From the challenges mentioned in this paper, two follow-up points emerged. Firstly, there is a clear need for the cruise liners to adapt to the future and changing conditions of the MIZ. Indeed, if the iconic wildlife is migrating because of habitat changes, cruise liners will have to 'follow' the species in order to maintain the last chance tourism niche. Secondly, and following the first remark, Stewart et al. (2007) rose the following question: 'if the MIZ's wildlife disappear or move somewhere else, will tourists keep visiting those fauna-deserted areas?' Such a situation could lead to potentially negative impacts for local communities who were largely benefiting from, or even dependent on, the tourism industry.

Finally, the interdisciplinary approach used in this article brought together academics from tourism studies, oceanography, biology and governance, in order to better reveal the relationship between cruises in the Arctic, and precise impacts of climate change not only on the MIZ, but also for the tourism industries that depend on it. Such interdisciplinary strategies are imperative in understanding the future of the Arctic environment and its associated industries under the impact of climate change. More so, it presents the ideal opportunity to open dialogue between science, policy and industry, to encourage the sustainable development of this unique and changing Arctic region.

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