

# The Impact of Sea Ice on Cruise Tourism on Svalbard

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**ABSTRACT.** This paper explores the relationship between sea ice conditions and cruise tourism activities in the Arctic Archipelago of Svalbard. It analyzes how cruise tourism planning and organization depend on sea ice conditions and to what extent Arctic climate change influences tourism. A mixed-method approach, including sea ice analysis and interviews with 13 cruise tourism stakeholders, was applied to grasp the complexity of Svalbard's cruise tourism. The outcomes show that cruise traffic depends on the sea ice cover, but only to some extent. Other factors, such as a location's attractiveness or sailing regulations also influence cruise itineraries around Svalbard. Sea ice conditions are in general considered favorable for cruising around Svalbard, and sea ice is not a decisive factor in cruise planning and organization. The sea ice cover around Svalbard is decreasing; thus, high annual and inter-annual unpredictability of sea ice poses challenges for cruise operations around Svalbard. Flexibility in itineraries, plus good cooperation and management help the cruise industry adjust to any challenges arising from uncertain sea ice conditions. However, issues of overcrowding and decreased attractiveness due to disappearing ice are more and more visible and may challenge the development of cruise tourism around Svalbard in the future.

**Key words:** Arctic; tourism; cruise tourism; sea ice; Svalbard; climate change

**RÉSUMÉ.** Cet article porte sur la relation qui existe entre l'état de la glace de mer et les activités du tourisme de croisière dans l'archipel arctique du Svalbard. Il se penche sur la manière dont la planification et l'organisation du tourisme de croisière dépendent de l'état de la glace de mer ainsi que sur l'ampleur de l'influence du changement climatique de l'Arctique sur le tourisme. Pour comprendre la complexité du tourisme de croisière du Svalbard, nous avons adopté une méthode à plusieurs volets, dont l'analyse de la glace de mer et des entretiens avec 13 organismes de tourisme de croisière. Cette étude a permis de déterminer que le trafic de croisière dépend de la couverture de glace de mer, mais seulement dans une certaine mesure. D'autres facteurs peuvent aussi influencer l'itinéraire des croisières dans le Svalbard, dont l'attrait de l'emplacement et les règlements de navigation. De manière générale, l'état de la glace de mer est favorable aux croisières dans le Svalbard, si bien que la glace de mer ne constitue pas un facteur décisif dans la planification et l'organisation des croisières. Dans le Svalbard, la couverture de glace de mer diminue. Par conséquent, la forte imprévisibilité annuelle et interannuelle de la glace de mer présente des défis pour les exploitants de croisières dans la région. La souplesse des itinéraires, alliée à une bonne collaboration et à une bonne gestion, aide l'industrie des croisières à relever les défis découlant de l'état incertain de la glace de mer. Toutefois, les problèmes liés à la fréquentation excessive et à l'attrait réduit de l'endroit en raison de la fonte des glaces sont de plus en plus apparents et risquent de compliquer le développement du tourisme de croisière dans la région du Svalbard à l'avenir.

**Mots clés :** Arctique; tourisme; tourisme de croisière; glace de mer; Svalbard; changement climatique

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## INTRODUCTION

Tourism is a growing industry in the Arctic (Larsen and Fondahl, 2014) and even the most remote High North locations, such as Svalbard, Greenland, and the Canadian Arctic, are receiving more and more tourists, mostly arriving onboard cruise ships (Snyder and Stonehouse, 2007; Stewart and Draper, 2008). In the High Arctic, Svalbard is the most popular cruising destination, with around 50 000 passengers annually (Governor of Svalbard, 2015; AECO, 2019), coming both on large, conventional cruise ships and on smaller expedition vessels, with up to

300 passengers, which are better suited to sailing in the severe Arctic conditions and making landings in remote locations. Next to mining and research, tourism is the main pillar of Svalbard's economy (Viken, 2011; Eeg-Henriksen and Sjømæling, 2017), where it is now an international, modern, and well-managed industry (Viken, 2011; Hagen et al., 2012; Van Bets et al., 2017).

However, climate change is increasingly influencing the Arctic environment, including Svalbard, and its consequences, such as melting sea ice or shifting weather patterns, may have a negative impact on cruise tourism activity (Lamers and Amelung, 2010; Rauken and Kelman,

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2012). Sea ice changes attract attention in this regard, as sea ice is the single greatest obstruction to ship navigation in the Arctic (Stephenson et al., 2011). The melting Arctic is often seen as promising for cruise tourism development (e.g., Lasserre and Pelletier, 2011; Stephenson et al., 2013; Pizzolato et al., 2014), but other research has revealed the greater complexity of this relationship, showing both positive and negative aspects of sea ice reduction for cruise tourism (e.g., Stewart et al., 2007, 2010; Stewart and Draper, 2008; Lasserre and Têtu, 2015). This growing literature has so far focused on the Canadian Arctic, with evidence from other Arctic destinations lacking.

At the same time, sea ice conditions vary across the Arctic (Onarheim et al., 2014), thus the nature and scale of sea ice change and consequently the impact on cruise tourism, may very well differ between, for example, Canada and Svalbard. Studying such changes locally is therefore pertinent to understanding sea ice impacts on cruise tourism which, in the Arctic, is mostly nature-based and depends on the condition and quality of the natural environment (Valentine, 1992; Heslinga et al., 2017). Understanding environmental changes and local responses to them sheds light on the necessary adaptations that will have to be made by the tourism industry. The adaptive capacity and flexibility of tourism providers are considered crucial elements of tourism growth in the Arctic (Johnston et al., 2012b), and the success of tourism operators depends on their ability to react to negative aspects of climate change and take advantage of the opportunities that arise (Scott et al., 2008).

This paper analyzes sea ice conditions around Svalbard and their changes in the recent decade. It also investigates the cruise tourism industry's planning and organization in relation to sea ice in order to better understand the impact of sea ice on cruise tourism organization and distribution and to draw conclusions about the necessary adaptations. It focuses on cruise operators as stakeholders that directly interact with the sea ice and take part in shaping the tourism destinations (Bystrowska and Dawson, 2017). The paper explores in more detail the relation between sea ice and cruise tourism on Svalbard: what the positive and negative aspects of sea ice change are for cruise operators, how the cruise industry responds to and deals with sea ice and what role sea ice plays in relation to other cruising factors. To better capture the complexity of the tourism-sea ice relationship, a mixed-method approach was applied, combining data on sea ice conditions with cruise tourism operators' interpretations and knowledge of sea ice change, as well as their responses in the context of adaptation.

The paper adds to the existing literature on Svalbard's tourism, which has so far focused mostly on management issues (e.g., Viken, 2011; Van Bets et al., 2017) or on the impacts of climate change, but mostly in the context of weather (Kelman et al., 2012; Hoarau et al., 2014). Exploring the role of sea ice in Svalbard's cruise tourism will help in better understanding the complexities of Arctic tourism growth and hopefully contribute to its better

organization and planning. The results also contribute to the debate on the role of climate change in Arctic tourism by exploring sea ice impacts around Svalbard, a location where the cruise tourism-sea ice relationship has not been investigated before.

## ARCTIC CLIMATE CHANGE AND TOURISM

Climate change is a widely discussed topic in the context of tourism, especially nature-based tourism (Becken and Hay, 2007; Hall, 2008). In nature-based tourism, the relationship between humans and the natural environment is particularly strong (Wall, 1996), making such tourism sensitive to changes in the natural environment, such as climate, weather, and sea ice conditions. All these changes may influence not only the attractiveness of sites, but also the feasibility and profitability of the tourism business (Saarinen and Tervo, 2006; Rauken and Kelman, 2012).

Climate change is a pertinent issue in the Arctic, where effects such as increased temperatures and precipitation and melting sea ice are occurring faster than in other parts of the world (IPCC, 2014a). Those changes have a direct impact on Arctic cruise tourism (Dawson et al., 2007). One of the most visible climate change effects in this regard is sea ice change, to which cruise tourism is particularly vulnerable (Stewart et al., 2007). Research from the Canadian Arctic shows that marine tourism development there is partly related to a decrease in sea ice (Stewart et al., 2013, 2015), although other factors, such as logistical constraints and regulations, also play a role in tourism distribution and growth (Lasserre and Têtu, 2015; Pashkevich et al., 2015). Studies have shown that sea ice melting can have positive implications for cruise tourism, but also poses certain challenges (Stewart et al., 2007; Pizzolato et al., 2016). Less sea ice improves the accessibility of tourism areas and contributes to better navigation. At the same time, floating multiyear ice and icebergs from calving glaciers can pose a hazard for sailing, and a lack of sea ice lessens the attractiveness of Arctic tourism sites (Stewart et al., 2007; Howell et al., 2009). Some ice-associated marine mammals in the Arctic, such as walrus or polar bears, both of which are great tourism attractions, already change their distribution, abundance and even body condition in response to the sea ice decrease (Kovacs et al., 2011). In addition, the use of ice-strengthened vessels while operating in Arctic conditions is a constraint many operators need to meet in order to enter the business, as in the Canadian Arctic (Lasserre and Têtu, 2015).

Climate change can thus be a source of both opportunities and challenges for tourism activities. The way cruise tourism operators respond to those opportunities and challenges determines the industry's survival and growth at destinations (Johnston et al., 2012b). Adaptive capacity, sometimes referred to as resilience capacity (Folke et al., 2002), enables tourism to survive and develop despite changes in the external environment. It defines the tourism industry's capacity to learn, evolve, and adjust to

the changing surroundings (Farrell and Twining-Ward, 2004). Adaptation is “the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities” (IPCC, 2014b:5). Examples of cruise tourism adaptations to climate change can be the setting of new industry regulations, such as emission targets (Eijgelaar et al., 2010), establishing cooperation within tourism industry networks (Van Bets et al., 2017) or tourism innovation (Hjalager, 2010).

However, our understanding of how climate change is actually affecting cruise tourism in the Arctic is still limited (Scott et al., 2001). It can be a source of both opportunities and threats, and some changes may not be relevant for cruise tourism at all. To assess the future of Arctic tourism and tourism adaptation to climate change, a better understanding of the nature of the changes, as well as their observed and potential consequences is needed together with stakeholders’ perceptions and responses. The existing literature on the role of sea ice in Arctic cruising focuses on the potential consequences and rarely addresses stakeholders’ perspectives (for exceptions, see Johnston et al., 2012b; Lasserre and Têtu, 2015). Seeking to help fill this research gap, this study combines both approaches by analyzing sea ice conditions together with cruise operators’ responses to changing sea ice to understand better climate change impacts on cruise tourism, as well as how the cruising industry adapts.

## SVALBARD AS A CRUISE TOURISM DESTINATION

### *Sea Ice Conditions around Svalbard*

Sea ice changes are, next to the changing weather, one of the most visible consequences of Arctic climate change (Rauken and Kelman, 2012). One of the most often used indicators is sea ice extent. Sea ice extent is defined as the area of the ocean with a fractional ice cover (i.e., ice concentration) of at least 15% (Serreze et al., 2007), while concentration is the relative measure of the proportion of ice compared to some reference area (NSIDC, 2019c). The evidence shows that overall sea ice extent in the Arctic is continually decreasing (e.g., Serreze et al., 2007; Parkinson and Cavalieri, 2008; Kwok et al., 2009; Wang and Overland, 2009; Stroeve et al., 2012; Onarheim et al., 2014; Serreze and Meier, 2018). The Arctic sea ice extent at the end of the melt season in September has been dropping significantly, at a rate that has been estimated at  $-7.8\%$  per decade (Stroeve et al., 2007) or  $-3.5\%$  to  $-4.1\%$  per decade (IPCC, 2014a). In 2016, the September minimum sea ice extent reached a record low, equal to the one reported in 2007 (NSIDC, 2019b). Onarheim et al. (2014) pointed out that the ice loss is now visible for all months and in all regions of the Arctic, but varies substantially between regions, time of year, and inter-annually.

In the case of Svalbard, two water masses surround the Archipelago—Atlantic water flowing in from the south and Arctic water entering from the polar ocean (Evenseth and Christensen, 2011)—a fact that has implications for the sea ice regimes. Consequently, sea ice conditions differ significantly between western and eastern Svalbard. Heat transport via the West Spitsbergen Current (WSC) is responsible for a warmer local climate and relative lack of sea ice on western Svalbard (Piechura and Walczowski, 2009; Muckenhuber et al., 2016). At the same time, eastern Svalbard borders the Barents Sea, which is one of the Arctic regions with the greatest sea ice variability at different time scales (Koenigk et al., 2009) and brings more sea ice to the east.

Researchers have observed a general decrease in sea ice around Svalbard; analysis by the Norwegian Meteorological Institute shows that the melting season around Svalbard starts earlier today than it did 40 years ago, and that the total ice extent has diminished by approximately 11% between 1967 and 2007 (Norwegian Meteorological Institute, 2007). Onarheim et al. (2014) studied sea ice north of Svalbard and reported that it has been decreasing for all months since 1979, with the largest reductions during the winter months. Also, Piechura and Walczowski (2009) analyzed the role of WSC heat transport fluctuations on sea ice distribution around Svalbard and observed sea ice reductions north of Svalbard. Examples of other studies related to sea ice on Svalbard include a study of Isfjord and Hornsund (Muckenhuber et al., 2016) and a series of analyses of sea ice conditions in Hornsund during winter (e.g., Styszyńska and Rozwadowska, 2008; Kruszewski, 2010, 2011, 2012). Given that sea ice can vary drastically over the years, more updated sea ice data were needed for this analysis. Therefore, this paper adds more recent data on sea ice, which also includes types of sea ice concentration and monthly variations in sea ice conditions—aspects that have so far been lacking in Svalbard research.

### *Cruise Tourism on Svalbard*

The Svalbard archipelago (Fig. 1) has been attractive for marine tourism because of its combination of accessibility, unique governance system, and the possibilities of various nature-based activities (Kelman et al., 2012). Around 65% of the Svalbard land area and about 86% of its territorial waters are under environmental protection (Lier et al., 2009). This protection is due to its rich and diverse wildlife, including bird colonies, land mammals such as reindeer and Arctic foxes, as well as polar bears, walrus, seals, and whales found in the seawaters around Svalbard. At the same time, Svalbard is one of the most northerly populated places on earth, with a population of around 2500 inhabitants living mostly in the capital of Longyearbyen, the Russian mining settlements of Pyramiden and Barentsburg, and the research community of Ny-Ålesund.

Today Svalbard is one of the most visited cruise tourism destinations in the High Arctic. In 2014, 47 637

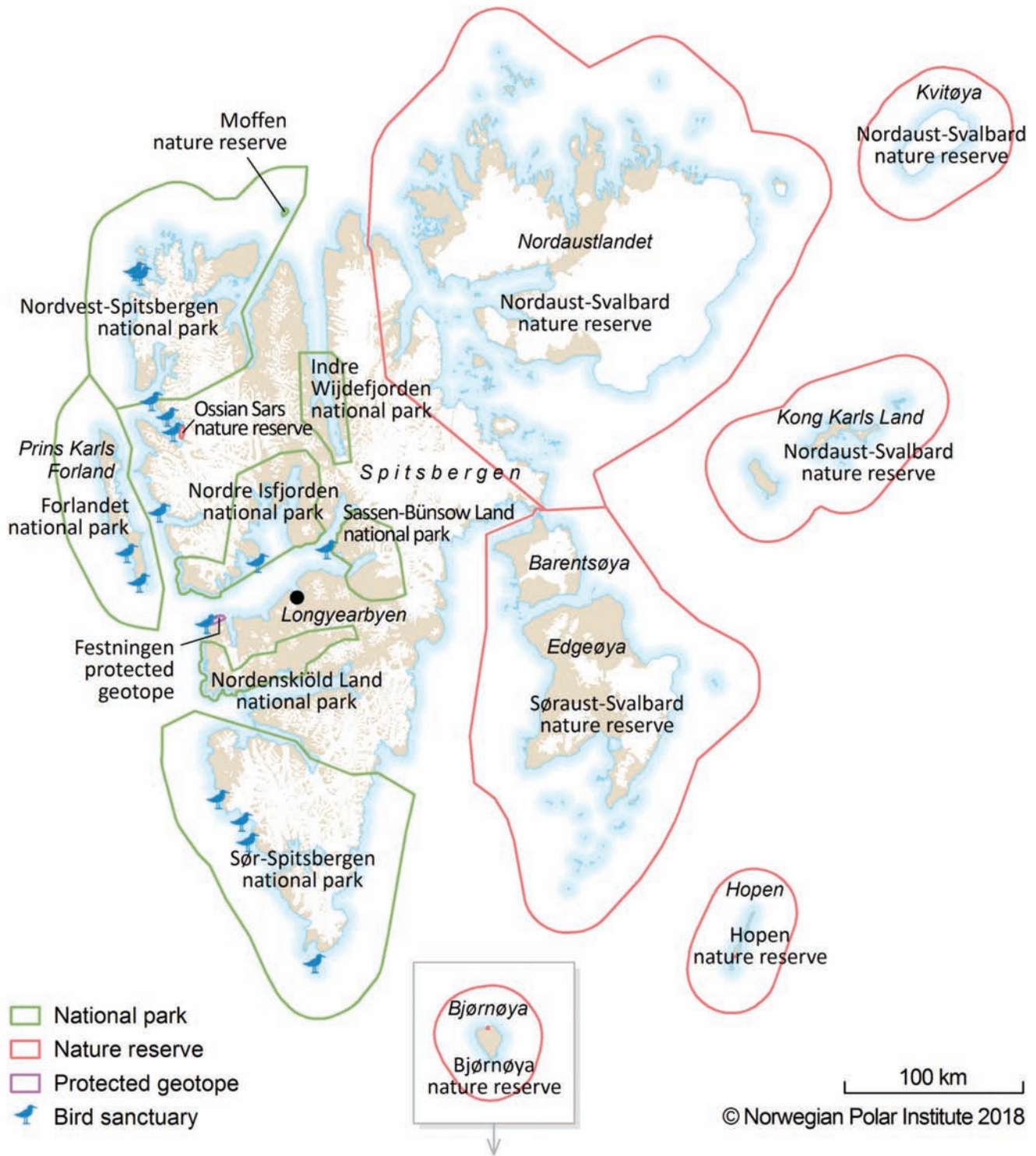


FIG. 1. The islands of Svalbard, with national parks and nature reserves shown. Map courtesy of the Norwegian Polar Institute.

cruise passengers visited Svalbard, coming on 182 cruises (Governor of Svalbard, 2015). The number of expedition ships to Svalbard grew from 14 in 2001 to 35 in 2014, with an attendant increase in the number of passengers from 3417 to 12 519 (Governor of Svalbard, 2015). It should be stressed that these are expedition passengers, who explore distant parts of the archipelago and make landings at nature

sites; conventional cruise ships, on the other hand, are restricted to the Isfjord area.

Cruise tourism on Svalbard has so far attracted attention from researchers mostly because of its model management frameworks provided by both the Governor's regulations and self-management by the Association of Arctic Expedition Cruise Operators (AECO) (e.g.,

Viken, 2011; Hagen et al., 2012; Van Bets et al., 2017). AECO is especially active on Svalbard, where it sets strict guidelines and management rules for visited landing sites (Bystrowska et al., 2017; Van Bets et al., 2017). It also controls and coordinates landings via a site booking system. AECO members register their itineraries in the online system before the sailing season and book planned landings; however, they also communicate while cruises are underway and can make changes in landings as long as limited pressure on the environment and regulation compliance are ensured. This system is partly integrated into the Governor's landing site regulations, which set limits for cruising activity in terms of possible landings.

The Governor of Svalbard identifies 465 official landing sites, and statistics are available for 1996 to 2015 (Governor of Svalbard, unpubl. data). The highest numbers of cruise passengers at all landing sites were reported in 2012 (119 386), 2013 (109 264) and 2014 (102 914). Since 2012, the numbers of passengers on land have been decreasing, but still remain higher than before 2012. Most cruise visits are made to western Svalbard: Ny-Ålesund in the Kongsfjorden area, the Trinityhamna/Gravneset site in the Magdalenefjorden area, the Selbukta site in the Hornsund area, and the Barentsburg and Piramiden sites in the Isfjorden area. Between 1996 and 2015, most passengers landed in the areas of Kongsfjorden (433 140), Nordvesthjørnet (325 193), Isfjorden (159 572), Hornsund (153 360), and Krossfjorden (75 120). Together these five areas, all located in western Svalbard, received around 72.5% of all passengers. For example, the average number of passengers per site for Kongsfjorden is seven times higher than Svalbard's average. In total in the years 1996–2015, 1 360 873 passengers landed in western Svalbard, whereas only 219 675 landed in the east—84% less than in the west. In eastern Svalbard, most visits were recorded in Edgeøya (51 104), Nordaust-Svalbard (34 268), and Hinlopen Østside (33 053) (Fig. 2).

## METHODS

This paper utilizes a case study (Stake, 2005) and mixed-method approach to research (Castro et al., 2010, Creswell and Creswell, 2018). The mixed-method approach means “the collection or analysis of both quantitative and qualitative data in a single study, in which the data are collected concurrently or sequentially, are given a priority, and involve the integration of the data at one or more stages in the process of research” (Creswell et al., 2003:212). Such an integration of data enables the full complexity of the studied phenomenon to be better grasped and allows conclusions to go beyond those attainable based on just one data type. The design applied is so called “explanatory sequential” (Hanson et al., 2005), which means that the quantitative data were collected and analyzed first, followed by qualitative data from the interviews; these interviews were designed based on the observations from the

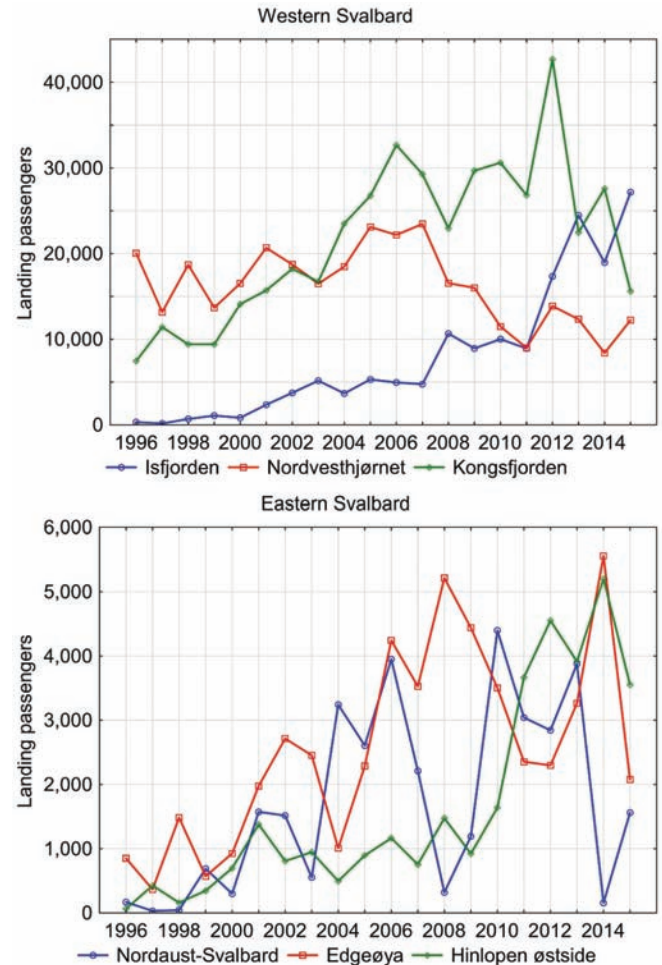


FIG. 2. Number of cruise passengers landing on the most popular sites on Svalbard between 1996 and 2015.

quantitative analysis, but no priority was given to a certain type of data. All data were considered equally crucial for results and interpretation.

## Sea Ice Data

The sea ice analysis covered 977 daily maps of sea ice extent and concentration for May–September between 2008 and 2017, provided by the Norwegian Meteorological Institute (NMI) in its online archive (<http://157.249.32.242/archive/>). NMI produces daily ice charts showing five types of sea ice concentration based on satellite measurements: fast ice, very closed drift ice (VCDI), closed drift ice (CDI), open drift ice (ODI), and very open drift ice (VODI). An overall area of 253 565 km<sup>2</sup> was studied, including all the islands of Svalbard except Bjørnøya, so as to cover the waters potentially visited by cruises.

The analysis was based on calculating sea ice extent at various concentrations. As VODI shows a concentration of at least 10%, a borderline of 10% was used to characterize the open-water border, which differs from the usually used borderline of 15% (Serreze et al., 2007). Calculations were made in ArcMap 10.4.1. software (ESRI), by using

TABLE 1. Sea ice extent calculations in Arcmap.

Total study area	2008–14 From raster calculator	2015–17 From raster calculator
Fast ice	("imagec1" ≥ 109) & ("imagec1" ≤ 149) & ("imagec2" ≥ 110) & ("imagec2" ≤ 135) & ("imagec3" ≥ 99) & ("imagec3" ≤ 135)	"imagec2" = 150
Very closed drift ice	("imagec1" ≥ 159) & ("imagec1" ≤ 254) & ("imagec2" ≤ 49) & ("imagec3" ≤ 49)	("imagec1" = 255) & ("imagec2" = 0) & ("imagec3" = 0)
Closed drift ice	("imagec1" ≥ 200) & ("imagec1" ≤ 255) & ("imagec2" ≥ 165) & ("imagec2" ≤ 181) & ("imagec3" ≤ 100)	"imagec2" = 125
Open drift ice	("imagec1" ≥ 200) & ("imagec1" ≤ 255) & ("imagec2" ≥ 230) & ("imagec2" ≤ 255) & ("imagec3" ≤ 150)	("imagec1" = 255) & ("imagec2" = 255) & ("imagec3" = 0)
Very open drift ice	("imagec1" ≤ 100) & ("imagec2" ≥ 200) & ("imagec2" ≤ 255) & ("imagec3" ≤ 100)	"imagec3" = 150
Black lines	("imagec1" ≤ 50) & ("imagec2" ≤ 50) & ("imagec3" ≤ 50)	"imagec1" = 0
Land area	("imagec1" ≥ 208) & ("imagec1" ≤ 215) & ("imagec2" ≥ 208) & ("imagec2" ≤ 215) & ("imagec3" ≥ 208) & ("imagec3" ≤ 215)	"imagec1" = 196

raster calculator formulas (Table 1). Different formulas were used for the years 2015–17 than those for the other years because of differences in color values between the maps. The sea area surrounding Svalbard was on average 198 574 km<sup>2</sup>, and the difference in sea area between maps was around 0.84% as a result of different degrees of accuracy in the representation of the islands on the maps, as well as potential geo-referencing errors made by the author. Another potential error relates to the 'black lines,' which are all separating lines and marks on the images. The average black pixel coverage for all studied pictures is 4.3%, around 11 000 km<sup>2</sup>. Given the usual inevitable errors in identifying sea ice limits and their precise calculations (Muckenhuber et al., 2016; Pastusiak, 2016), the errors listed above are of similar order and are deemed acceptable for this study.

The sea ice data were used to prepare the maps, which show the approximated high-concentration (more than 70%) sea ice occurrence around Svalbard in four summer months between 2008 and 2017. To prepare the map for a selected month, maps from the beginning, middle, and end of the month in a 10-year period were qualitatively assessed. The studied area was divided into sectors; for each sector

TABLE 2. Overview of research participants.

Participant's number	Position
1	Expedition leader
2	Cruise tourism organization secretariat
3	Cruise captain
4	Cruise company management
5	Cruise company management
6	Cruise company management
7	Expedition leader
8	Cruise company expedition planner
9	Port Longyearbyen employee
10	Cruise company – cruise coordinator
11	Expedition leader
12	Cruise company management
13	Cruise tourism organization secretariat

the presence of sea ice of high concentration was assessed and recorded if: a) sea ice of high concentration covered a large part of the sector, b) sea ice of high concentration was visibly blocking the entrance to the sector (e.g., a particular fjord) or passage through the sector. The assessment was done manually by the author, which may be a source of potential error. Based on this assessment, four types of areas were identified, depending on how often sea ice of high concentration was present during each month: 1) none or episodic high-concentration sea ice (present 5 days or less during the month); 2) rare high-concentration sea ice (6–10 days out of 30); 3) moderate high-concentration sea ice (11–20 days); and 4) often high-concentration sea ice (21 to 30 days). The categories were selected ad hoc by the author to best show the differences between sector areas and months.

#### Interview Data

In-depth interviews were chosen as a research tool in order to encourage research participants to comment freely and add new themes to the broader research topic. Thirteen in-depth interviews with cruise tourism stakeholders on Svalbard were conducted (Table 2). The interviews took place in 2015–17, after the initial conclusions from the sea ice analysis, which influenced the interview part. Interviews were conducted in English, via Skype, by telephone, or in person and lasted between 20 and 90 min. All responses have been kept confidential. The interviews were transcribed and approved by the respondents to ensure reliability of data. During the interviews, research participants were asked to express and discuss their opinions about Arctic cruise tourism development in light of climate change and how they think sea ice is and will be influencing marine tourism on Svalbard. The questions also related to cruise ship planning and organization.

All research participants had extensive knowledge and experience in the Arctic regions, including Svalbard, hence they were able to discuss sea ice changes over the recent years for the specific location. All the participants were involved in expedition type cruises and represented companies that are part of a collaborative network. The

secretariat of this organization was also interviewed. It should be noted that, except for the secretariat responses, the responses represent the personal opinions of a research participant, not the official position of the company they represent. Obtained data were coded and categorized thematically using the Atlas.ti 7 software (Scientific Software Development GmbH, Berlin), based on re-occurring themes: the positive and negative aspects of sea ice, the role of sea ice among other factors, and responses and adaptations to changing sea ice (Saldaña, 2015).

## RESULTS

### *Sea Ice Changes on Svalbard*

The concentration of sea ice is a crucial characteristic for assessing its impact on cruising. In the study area, very closed drift ice (VCDI), with a concentration of 9–10/10 (90%–100% of the area), accounts for most of the ice cover (Fig. 3) and this type of sea ice concentration is the most challenging for sailing. It occurs mostly in the early sailing months of May and June, but is also present in later months, especially in eastern and northern areas of Svalbard. VCDI may sometimes flow into certain fjords during the sailing season, even reaching the fjord's end. In 2011, episodes of fast inflows of VCDI into southwestern fjords, such as Hornsund, which is a popular cruising destination, were caused by southern currents. Although VCDI dropped by around 80% between 2008 and 2016, it increased significantly again in 2017, showing high annual unpredictability. The same trend has been observed for other types of sea ice concentration.

Fast ice, which is anchored to the shore or ocean bottom and is defined by the fact that it does not move with the winds or currents (NSIDC, 2019a), occupies the smallest share of the study area, but it is a constraint for shore visits of cruise ships. At first it can be thin (e.g., around 30 cm), but it may grow in thickness and expand to an extent that precludes ship operations (Pastusiak, 2014). On Svalbard, fast ice usually lasts until mid-August in certain shore areas and melts almost completely through the sailing season. During the study period, the fast ice extent fluctuated but showed a decreasing trend overall. Between 2016 and 2017 there was an increase of 527%; despite such an increase, the total area covered by fast ice is relatively small compared to other types of ice. Fast ice is often present in the fjords early in the sailing season in western Svalbard areas, such as Kongsfjorden and Magdalenefjorden, where it can affect sailing. More fast ice can be found, for example, around Nordasutlandet island or in Wijdefjorden, in northern Svalbard.

During the sailing season, sea ice occurs mostly in the northern and eastern parts of Svalbard (Fig. 4). For example, Hinlopen Strait, through which circumnavigations take place, was blocked with fast ice until June 2008, but in June 2012, there was almost no ice in the Strait. There

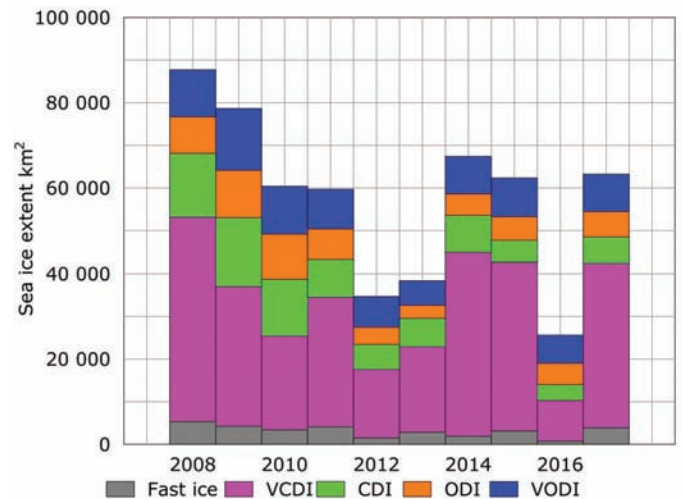


FIG. 3. Sea ice extent by ice concentration type for May–September around Svalbard (sailing season average). VCDI = very closed drift ice, CDI = closed drift ice, ODI = open drift ice, and VODI = very open drift ice.

have also been rapid flows of VCDI, such as in July 2009, or episodes of the northern entrance to the Strait being blocked by VCDI, such as in June 2013. At the same time, the western parts of the archipelago are practically ice free during the sailing season, but episodic local variability in sea ice occurs. For example, the popular landing area of Kongsfjorden was usually blocked with fast ice in May during the study period, but aside from that it was easily accessible; much the same can be said for the northwestern fjords, such as Magdalenefjorden. Hornsund has however shown more unpredictability. For most of the study period there was usually fast ice in Hornsund in the early season, but in May 2012 there was no fast ice there. On the other hand, the analysis detected rapid episodes of VCDI drifts into the fjord, such as one in July 2011 that blocked the entrance to Hornsund, posing challenges for sailing.

Changes and unpredictability in sea ice extent occur not only annually, but also inter-annually. May is the month of the greatest sea ice extent throughout the studied period—99 841 km<sup>2</sup> on average and with a maximum in 2008 and 2017 (Fig. 5). Among the analyzed months, May remains the least favorable for sailing and rapid increases in sea ice extent, such as one seen in 2017, give rise to high uncertainty as to the start of the cruising season. For each month, a general decreasing trend is visible over the years, but significant variability between the years should be noted. The largest variation in sea ice extent was seen for September, with a maximum of 53 829 km<sup>2</sup> in 2014 and a minimum of 667 km<sup>2</sup> in 2013. The standard deviation from the mean monthly sea ice extent is 21 154 km<sup>2</sup> for May, over 22 000 km<sup>2</sup> for August and September and over 28 000 km<sup>2</sup> for June and July. The monthly sea ice extent often differs significantly from the mean value, showing both increases and decreases from the mean, which confirms the rather high unpredictability of sea ice conditions from year to year and inter-annually.

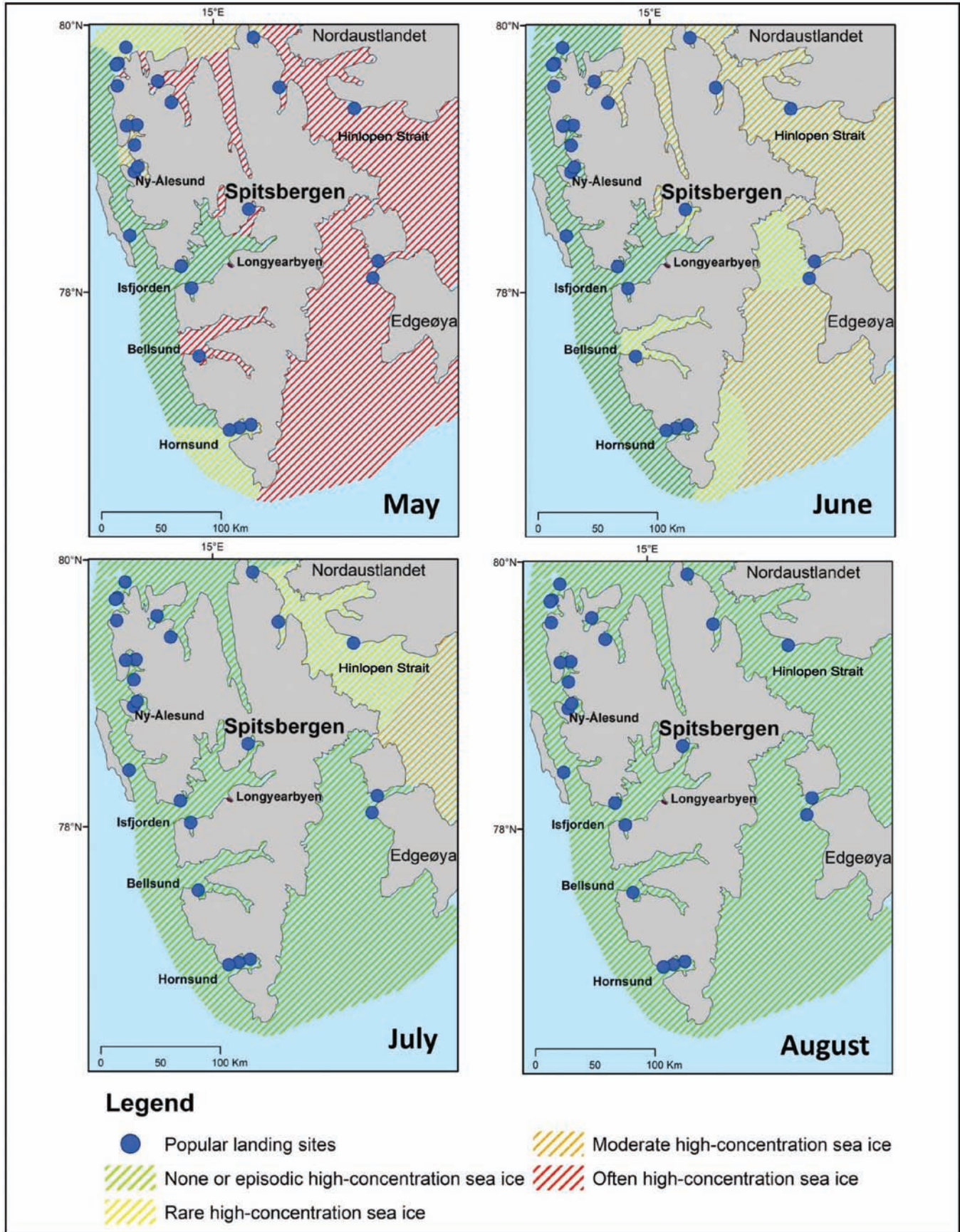


FIG. 4. Qualitative assessment of high-concentration sea ice occurrence during four summer months over a period of 10 years (2008–17) based on Norwegian Meteorological Institute data.



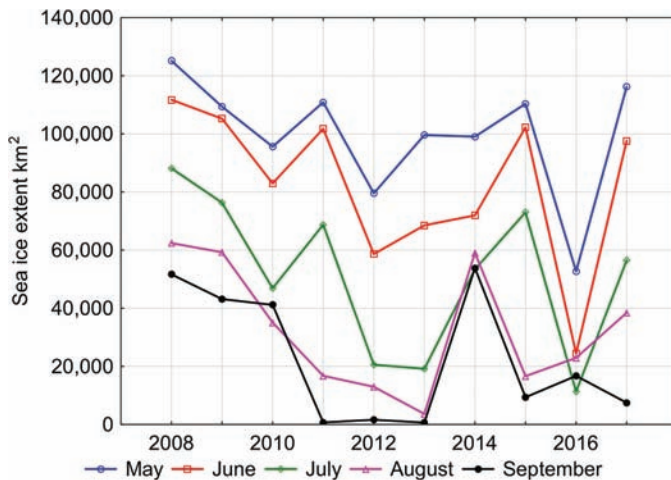


FIG. 5. Sea ice extent on Svalbard from May to September, 2008–17.

### *Cruise Operators' Perceptions of Sea Ice on Svalbard*

The conducted interviews shed more light on the sea ice observations above and, in general, identified issues also confirmed in the sea ice analysis: a general decreasing sea ice trend, high annual and inter-annual unpredictability, and local variability. Expanding the sailing season to the earlier months was often brought up as a pertinent topic, and various opportunities and challenges of sea ice were mentioned.

Most of the participants stressed the importance of the decreasing trend of Svalbard sea ice as an opportunity for cruising:

There are a lot of changes in the sea ice that I have experienced. We did not plan our circumnavigation until July-August. And now they have first circumnavigation already at the end of June. There is no problem.

Research Participant 1

Circumnavigation has become a popular cruise route offered in recent years. Sailing as far north of Svalbard as possible has also become a highlight for tourists. In addition to these new cruising opportunities, operators mentioned that one of the positive things about melting sea ice is the prolongation of the cruising season. Because of improving conditions, some operators start cruises earlier in the season, in May and even April, and extend sailing to September. But for some, expanding the season to May is risky, as the “situation is very unpredictable then” (research participant 9), an observation that corroborates the findings of the sea ice analysis.

Participants also stressed high annual and inter-annual variations in sea ice conditions, which pose a challenge for the planning and organizing cruises. Research participant 11 noted: “the sea ice issues are very complex and variations happen along the season. Climate change impact is not linear and trends are not obvious.” Considering the changing annual and local conditions, cruise operators on Svalbard are unable to plan exact routes based on the

sea ice conditions that occurred the year before—the unpredictability is too significant to rely on the fact that one year there was no ice in a certain fjord, as the next year may bring a completely different situation. For example, there was record low sea ice in May 2016 and good sailing conditions, but the following year 2017 showed challenging and icy conditions even in later sailing months.

Regarding the record high sea ice in 2017, participant 10 mentioned that their company was not able to complete the first circumnavigation until early August, because of too much sea ice prior to then. Research participant 11 also noted that in 2017 the company experienced problems with circumnavigation in July and stressed seasons in the past, where it was impossible to sail even in August. He also mentioned one season where conditions were favorable in May, but not in August because of rapid inflows of sea ice. This inter-annual variation in sailing conditions is in line with the findings presented previously on ice cover. All participants perceived the sea ice as unpredictable, especially in eastern Svalbard. This unpredictability is a restraining factor for organizing cruises there; in particular, for planning circumnavigations.

Cruise operators raised concerns about more uncertain and unfavorable conditions in the east, while western Svalbard remains a safer and more attractive option (research participants 1, 2, 7). As cruises are planned one to two years in advance, many cruise operators rely on the safe and well-known routes in western Svalbard rather than risking operations in more unknown conditions in eastern Svalbard (research participant 2), which partly explains the lesser traffic in the east. But research participant 6 expressed a different view by noting that “unpredictability can be a good thing: it creates a sense of adventure—the heart of expedition travel.” Thus, for some operators, sea ice and its unpredictable conditions can be an additional attraction and motivation for circumnavigation. Besides, sea ice was perceived as only one of numerous factors influencing cruise traffic and explaining the differences in cruising intensity between western and eastern Svalbard. Research participant 2 mentioned other decisive issues: the much stricter regulations in the east, time efficiency (more time required for circumnavigation), the higher costs of sailing to the east and higher attractiveness of landing sites in the west. These issues were also mentioned by other research participants as influencing cruising decisions.

At the same time, the decrease in sea ice in the east was seen by participants to be a potential contributor to expedition cruising development in response to crowding, which is becoming a pertinent issue on Svalbard (research participants 5, 7, 11). Because of overcrowding, for example around the Ny-Ålesund area, cruise operators search for new alternative locations to avoid other ships and ensure maintenance of the solitude aspect of expedition cruises. Eastern Svalbard is becoming attractive as it can help to solve crowding issue (research participant 7). Improving access to the northern and eastern parts of Svalbard can be an alternative for the overcrowding problem.

Interest in eastern Svalbard may increase in the future as operators observe a lack of sea ice in the areas they usually sail, which might lessen the attractiveness of the locations they offer. As research participant 5 noted: “On Svalbard we do not have much sea ice. It can be difficult to find sea ice, to go out. That is always a highlight.” Trips focused on polar bears can be especially challenging in the high season because of too little ice (research participant 11). A few cruise operators are already considering a reduction in their Svalbard program due to the lack of sea ice and consequent lesser attractiveness (research participants 5, 7, 8). Instead, they expect to explore new potential destinations, such as Arctic Canada and Arctic Russia. The small amount of sea ice in 2016 shows that the search for ice-covered landscapes and wildlife can be a challenging task for Svalbard’s cruises. The lessening attractiveness of tourism sites and overcrowding are substantial challenges for the future cruise tourism industry on Svalbard. Research participant 7 noted:

Technically of course it is making things easier, because ice can be an obstacle, but of course, from tourists’ perspective, ice is a part of the attraction of the Arctic, a very important thing for the nature and people want to see the ice; it shouldn’t get that far that there is no drift ice around Svalbard any time of the year. When Svalbard loses this High-Arctic touch, I think it will make it lose some of the attractions, and lose as a tourists’ place, but it is just a scenario.

On Svalbard, operators consider themselves capable of dealing well with the sea ice unpredictability, by being flexible and able to adjust to changing conditions. They prepare passengers for the possibility of an itinerary change due to weather or ice—itineraries are mostly drafted only in general terms. “Some operators even make a point of this flexibility, making passengers feel that they are truly on an expedition” (research participant 13). The same participant noted that cruising association members on Svalbard are very adept at finding alternative solutions to harsh and unpredictable conditions: “Thanks to our cruise database and vessel tracker, and good communication with fellow operators, the ships are able to plan a suitable new route if confronted with unnavigable ice.” These observations confirm that the cooperation and management framework for Svalbard’s cruising enhances adaptation to the unpredictable sea ice conditions in the form of flexible itineraries, ad hoc cooperation at sea, and self-regulatory management rules.

## DISCUSSION

The analysis confirms that sea ice on Svalbard is diminishing, which is in line with the findings of other studies (Piechura and Walczowski, 2009; Onarheim et al., 2014). It also adds to this research by stressing significant

local differences and high annual and inter-annual variability in sea ice conditions (Serreze and Meier, 2018), which leads to high unpredictability of sea ice conditions for sailing. Sea ice conditions are more favorable in western Svalbard, but inflows of sea ice, for example in Hornsund, are also likely to occur there. Additionally, ice of high concentration dominates, which poses a challenge to the safety and feasibility of marine operations, especially in eastern Svalbard and during the early months of the sailing season, mostly for ships without appropriate ice-strengthening. For cruise operators, the changes that have occurred in recent years—lessening ice cover, but with high unpredictability—are a source of both opportunities and threats.

### *Positive Aspects of Sea Ice Changes for Svalbard’s Cruising*

The observed sea ice loss on Svalbard is a potential opportunity for cruise tourism development due to better accessibility of certain areas, such as northern and eastern Svalbard. The research participants confirmed interest in circumnavigation and starting the season earlier, which makes the cruising portfolio more attractive and diversified and helps to avoid problems related to overcrowding in the high season. Circumnavigations are occurring more often, but they are challenged by the high sea ice unpredictability. As noted previously, during the record low sea ice in May 2016 conditions for circumnavigation were good, but in the following year much more ice restrained circumnavigation even in the middle of the season. In 2017 at least one vessel was forced to turn back from a planned circumnavigation, illustrating how the new sailing opportunities are still uncertain.

Also, the notion of starting the season earlier should be treated carefully. Despite the fact that, for example in Canada, earlier melting of sea ice suggests a consequent extension of the sailing season (Stewart et al., 2007; Howell et al., 2013), for Svalbard, the high variability of May sea ice extent and concentration suggests that a sailing season extension is still challenging for operations. A more visible and stable decrease in sea ice might be required to minimize the risk related to cruising in spring.

### *Negative Aspects of Sea Ice Changes for Svalbard’s Cruising*

Critical reductions of the sea ice on Svalbard, at least as observed for certain years, are already raising concerns about its decreased attractiveness for Arctic cruising activity. The presence of sea ice is part of the cruising experience and cruise operators depend on certain amounts of sea ice to provide an experience product (Stewart et al., 2007). Landing sites that are now attractive because of icebergs, walrus, or polar bears may lose tourists if these features are lost in the future, which becomes a concern for cruise operators. The evidence from Svalbard shows that the negative consequences of sea ice loss for cruise

tourism are likely to occur in the near future, which is also a concern for the Canadian Arctic (Stewart et al., 2010). The decreasing attractiveness of ice-free sites, together with crowding problems, may shift interest from destinations such as Svalbard to newly opened-up locations, such as in the Russian Arctic. Some operators are already considering moving to other destinations. Lacking typical Arctic attractions, the cruise tourism industry would potentially have to search for new locations or a new focus for cruising in the Arctic.

Moreover, sea ice unpredictability adds to the safety issues of cruising operations. Collisions with icebergs are a key concern, and Evenseth and Christensen (2011) point out that drifting ice can often be challenging for ship operations around Svalbard. The ice and the glaciers can sometimes also displace moraines on the seabed and thus change sailing depths (Evenseth and Christensen, 2011). The presence of more vessels with no ice-strengthening, because of perceived lesser ice amounts, may lead to the opposite effect—those ships may be ill prepared if the sea ice changes quickly and they encounter floating ice.

#### *Sea Ice and Other Cruise Tourism Factors*

The positive and negative aspects mentioned above are crucial, but are not the only ones influencing cruise tourism activity on Svalbard. Sea ice data, compared with landing statistics, do not confirm unequivocally that less sea ice leads to more cruise tourism traffic (due to the short time frame of the study [10 years], statistical correlations were not tested). For example, none of the most visited eastern locations—Edgeøya, Nordaust-Svalbard, and Hinlopen Østside—showed peaks in tourism numbers during the record low ice seasons of 2012 and 2013. On the contrary, on Edgeøya tourist numbers were at one of the lowest levels in this period. In Hinlopen Østside they were lower than in 2014 when the sea ice level was one of the highest, whereas for Nordaust-Svalbard the numbers were high, but not as high as in 2010. Some examples do however show a positive relationship: the record low tourism volume in Nordaust-Svalbard was in 2014, when September ice was the greatest. Landing trends vary significantly between locations, which suggests that factors other than sea ice influence cruise traffic.

Western Svalbard is almost ice free during the sailing season and most cruises occur there, but stakeholders confirm that the area's popularity is also due to the greater attractiveness of wildlife and landscapes, and shorter distances from the Longyearbyen tourism hub. Environmental regulations also play a role in cruising distribution, since the Governor of Svalbard regulatory framework allows a limited number of passengers on land at a time. Additionally, new regulations limiting access to certain locations in eastern Svalbard came in force in 2014. The initial government proposal was to close all of the eastern Svalbard nature reserves (40% of Svalbard's land area). Although this proposal did not come into

force, it illustrates the direction towards restricting this part of the archipelago for cruising purposes. Another crucial factor for cruise traffic distribution on Svalbard is the management framework provided by AECO and the existing landing site-booking system, which controls and coordinates landing activities to ensure limited traffic.

The availability and strength of cruise vessels also play a role in relation to the sea ice. Sailing in the Arctic requires adapted vessels, suitable for the harsh Arctic conditions. The availability of ice-strengthened ships for expedition type cruises is limited, and the frequent occurrence of high ice concentrations requires appropriate safety measures. Higher sea ice concentration requires ships to have the appropriate ice class or polar class. Polar class defines a vessel's additional level of safety when navigating in icy waters. Seven polar classes are defined, ranging from PC 1 for year-round operation in all polar waters to PC 7 for summer and autumn operation in thin first-year ice (IACS, 2016; Pastusiak, 2016). Numerous cruise vessels on Svalbard have no ice-class or a low assigned class, which is sufficient when they visit only western parts of Svalbard. But for circumnavigations, ship appropriateness may pose a challenge in unpredictable sea ice conditions: safe sailing without a strengthened hull is possible when sea ice concentrations does not exceed 30%–40%, whereas with concentrations over 50%, an ice class vessel is necessary (Pastusiak, 2014). Given the often-occurring VCDI ice on Svalbard, many ships are not suitable for making sailings.

The above-mentioned factors are in line with evidence from the Canadian Arctic, where declining sea ice is not the only factor in cruise tourism development (Johnston et al., 2012a; Pizzolato et al., 2014, 2016; Dawson et al., 2016). For Canada the crucial restraining factors include a complex regulatory system (Dawson et al., 2014; Lasserre and Têtu, 2015; Pashkevich et al., 2015), as well as the availability of ice-strengthened vessels (Stewart et al., 2007, 2013; Dawson et al., 2014; Pizzolato et al., 2016). While the regulatory system on Svalbard is rather simple and favorable (Hagen et al., 2012; Van Bets et al., 2017), certain environmental regulations, vessel availability, and local attractiveness add complexity to the organization and distribution of cruise tourism on Svalbard.

#### *Cruise Operators' Responses and Adaptation to Sea Ice*

The high adaptive capacity of the cruise tourism industry on Svalbard is most evident in relation to sea ice unpredictability, which makes it difficult to plan and organize cruises and requires adaptive measures on the part of the cruise tourism industry (Lamers and Amelung, 2010). Because of the unpredictability of sea ice, but also other conditions such as the weather, cruise itineraries are only drafted in general terms and changes often occur while on route. Cruise operators plan safe routes and usually choose those that are well-known and predictable. Moreover, some operators turn the unpredictability of natural conditions into a marketing advantage by advertising this unpredictability

as part of the experience and adding a sense of adventure to the organized sailings.

Cruise operators manage to deal with unpredictable sea ice conditions, and also other kinds of unpredictability, thanks to close collaboration within the industry (Van Bets et al., 2017). For conventional cruise operators, the local cruise coordinator provides support in operations. In expedition cruise tourism, AECO helps to coordinate and manage operations, for example, through an online landing site-booking system and vessel-tracking system. The findings of this study show that the cruise tourism industry on Svalbard demonstrates an ability to deal with environmental unpredictability and change and to ensure minimized impact on the environment at the same time (see also Evenseth and Christensen, 2011). Cruise operators do not perceive sea ice as a major concern, as they are able to respond to changes and unpredictability, which are made an integral part of the cruising experience.

Flexibility, good organization, and cooperation make Svalbard's cruise tourism industry well-adapted to climate change effects. As the International Panel of Climate Change (IPCC, 2001:879) states: "Enhancement of adaptive capacity represents a practical means of coping with changes and uncertainties in climate, including variability and extremes. In this way, enhancement of adaptive capacity reduces vulnerabilities and promotes sustainable development." Cruise tourism on Svalbard is able to deal with uncertainty and change and to further develop at the same time, which confirms the good resilience capacity (Berkes et al., 2003; Folke et al., 2005; Folke, 2006). A close collaborative network and network management are present in Svalbard's cruise tourism and are seen as crucial for successful climate change adaptations (Luthe et al., 2012). Resilience is a fundamental part of tourism—to sustain their activities at a destination, tourism operators need to be able to deal with occurring changes (Heslinga et al., 2017). In this context, Svalbard can be seen as a model case study, where good cooperation, communication, and management frameworks support the cruise industry's adaptation to changing natural conditions, such as sea ice.

## CONCLUSIONS

Sea ice conditions on Svalbard are relatively favorable for cruise tourism activity, despite high annual and inter-annual unpredictability and high concentration. The unpredictability of sea ice conditions is a major challenge, which is well addressed by the cruise tourism industry in the form of flexible planning and organization of cruises, as well as close cooperation within the industry. Cruise operators are utilizing opportunities such as new routes or earlier sailings, but within the limitations of the unpredictable conditions. New challenges, such as reduced attractiveness and overcrowding, have become key management concerns for cruise operators and may contribute to reducing cruise traffic in the future, as cruise

operators may look for new, more attractive and less-crowded sites. Even though the industry has so far been well managed, the challenges presented in this paper pose a question for the future development of Svalbard's cruise tourism. The operators' experience and cooperation, as indicated in this study, suggest that the cruising industry has the capacity to deal with climate change consequences, such as changing sea ice, but a future without sea ice would require significant changes in the cruise tourism products that we know today.

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