Arctic shipping and risks

Emergency categories and response capacities

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Arctic Shipping and Risks: Emergency Categories and Response Capacities

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ABSTRACT: The sea ice in the Arctic has shrunk significantly in the last decades. The transport pattern has as a result partly changed with more traffic in remote areas. This change may influence on the risk pattern. The critical factors are harsh weather, ice conditions, remoteness and vulnerability of nature. In this paper, we look into the risk of accidents in Atlantic Arctic based on previous ship accidents and the changes in maritime activity. The risk has to be assessed to ensure a proper level of emergency response. The consequences of incidents depend on the incident type, scale and location. As accidents are rare, there are limited statistics available for Arctic maritime accidents. Hence, this study offers a qualitative analysis and an expert-based risk assessment. Implications for the emergency preparedness system of the Arctic region are discussed.

1 INTRODUCTION

An understanding of risk factors, risk mitigating tools, and adequate rescue system capacities in different areas is necessary for sustainable development in the Arctic. Safe maritime operations in the Arctic are challenged by limited infrastructure long distances between harbors, a sparse population and harsh weather conditions.

Activity and probability of accidents differ in various parts of the Arctic for geographical, economic and historical reasons. Marchenko, Borch et al. 2015 made an assessment algorithm and presented a risk matrix for several sea areas of the High North region (Norway and Russia west of Novaya Zemlya). Marchenko, Borch et al. 2016 considered available SAR resources and identified capacity gaps. In this paper, we elaborate on the range of challenges related to remoteness, risk of ice and icing, and limited government resources. The experience and challenges of this type of risk evaluation are discussed.

2 THE SEA REGIONS OF THE ATLANTIC ARCTIC

The Atlantic Sector is divided into five sea and land areas in accordance with the definition specified in the Artic Council's Search and Rescue (SAR) Agreement (Arctic Council 2011). A more fine-grained categorization is used in this paper where we look at the Russian Arctic by Novaya Zemlya and divide the Norwegian Sector into northern (Svalbard) and southern (Coastal) parts (see Figure 1).

These five regions radically differ from each other in terms of nature, ship traffic and infrastructure. In the western part of the Russian Arctic offshore oil and gas activity is emerging in ice-infested waters. In the Norway, the cruise industry are entering into the northernmost waters around Spitsbergen with larger vessels. Detailed characteristics of the eastern part (Norway and Russia) (Numbers 3–5 in Fig. 1) are given in (Marchenko 2015, Marchenko, Borch et al. 2015, Marchenko, Borch et al. 2016). This discussion shows that in the eastern part the capacities for emergency response is scarce when it comes to large scale incidents, where the larger cruise vessels represents a dominating threat. An important part of the risk assessment is thus the availability of both private and government emergency response resources that match the sea region activity. In Greenland (Region 1 on Fig.1), Denmark has the responsibility of emergency preparedness in open waters. This is a huge territory, with a small population concentrated in the south-western part. Only a few harbors, heliports and airports are located along the extensive coastline (only 15% not covered by ice). Engine failure in the small boat fleet, grounding and collision with ice are among the dominating risk factors. There are on average 80–90 SAR operations per year, performed by JRCC Greenland and police, and 200–300 persons in distress every year (Joint Arctic Command 2016).

Iceland (Region 2 on Fig.1) is the largest and warmest SAR-region among the Arctic five regions, with a rather sparse population concentrated in coastal areas, a developed harbor infrastructure in the south-western part and a rather intensive ship traffic. However, the number of fatal accidents at sea went down from on average 20 per year in the 1970s to two accidents in the last decades. The main risk factors for maritime traffic in the sea around Iceland are among others severe weather conditions related to ships' robustness and equipment; and fire on board far from the coast. The Icelandic Coast Guard (ICG) is the key SAR actor in this region with coordinative responsibility.

Figure 1. Considered Regions. Created on the base of Arctic Search and Rescue Agreement Map (Arctic Council 2011). 1-Greenland, 2-Iceland, 3-Svalbard, 4-Coastal Norway, 5-Russian sector of the Barents Sea

3 MARITIME ACTIVITY PATTERN

In this study, we have assessed the recent developments (last five years) in the ship traffic and maritime activity, using Arctic Havbase (Norwegian Coastal Administration 2017. The Arctic Havbase is an online resource providing monthly AIS data statistics since 2012. The number of port calls and passenger traffic over crossing lines are presented in Figure 2–5.

In all ports (except Hammerfest and Tromso), the amount of port calls has increased during the last five years. The larger the port, the more significant was the increase in activity. The decrease of calls in Hammerfest and partly in Tromso can be explained by lower oil and gas exploration activity resulting in less visits by the offshore service vessel fleet.

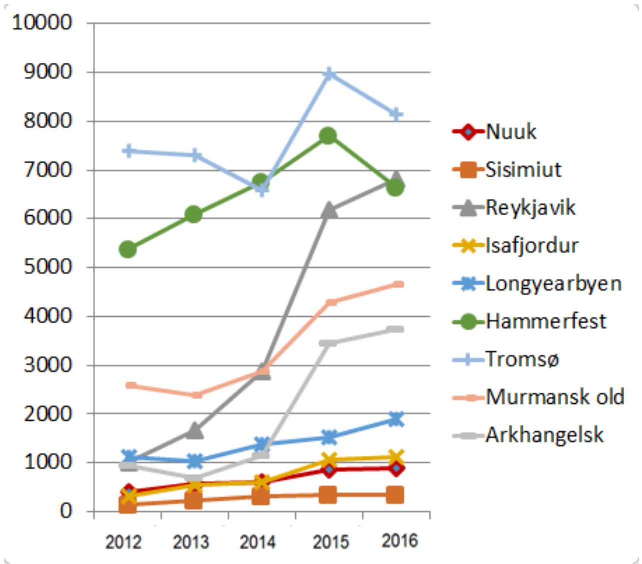


Figure 2. Number of port calls dynamics

The sizes of ports are clearly seen in the Fig.2. Greenland and Svalbard ports are much smaller than Coastal Norway.

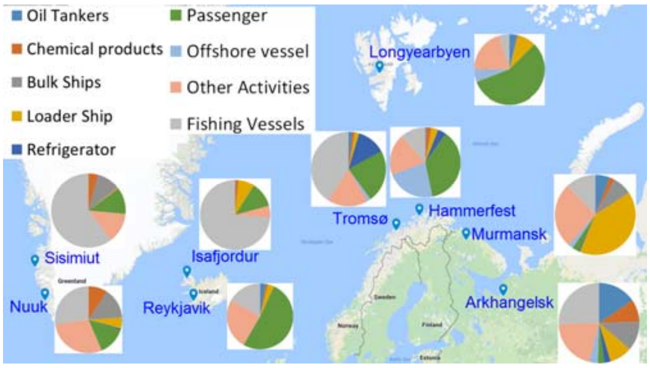


Figure 3. Type of vessels coming to Arctic Ports. Created on the base of (Norwegian Coastal Administration 2017)

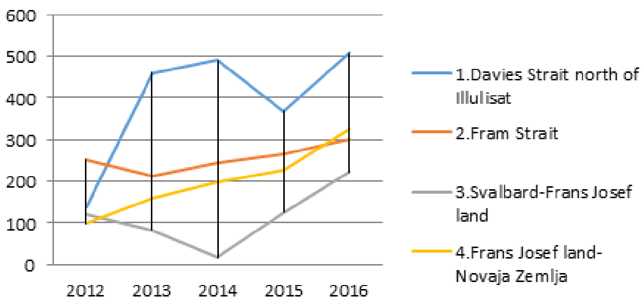


Figure 4. Number of passengers crossing conventional lines (data from (Norwegian Coastal Administration 2017)

The activity level in the far north remote waters can be estimated through the number of passengers crossing conventional lines (Figure 4), and through the type of vessels they were on (Figure 5) (Norwegian Coastal Administration 2017). The activity is fluctuating with fishing vessels and passenger vessel in majority.

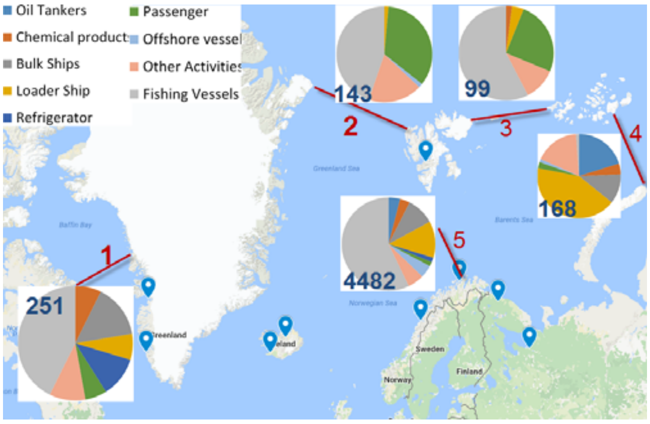


Figure 5. Types of vessels crossing conventional lines vessels (data from the Arctic Havbase (Norwegian Coastal Administration 2017). Red numbers – line number (see fig. 4). Blue numbers- total numbers of passengers in one direction.

4 RISK ASSESSMENT THEORY

Risk is difficult to define and estimate. In this study the starting point is the traditional risk definition emphasizing the estimated amount of harm that can be expected to occur during a given time period due to a specific event. Risk is then the product of the probability that an accident happens multiplied by the negative effects on health, environment and values that an accident may cause. A typical risk matrix has rows representing increasing severity of consequences of a released hazard and columns representing increasing likelihood of an accident to appear (Trbojevic 2000). On a standard risk matrix, red cells indicate high risk, yellow ones moderate, and green ones low (see risk matrix for Iceland as example -Table 2).

After identifying risk, measuring it, and estimating the consequences, a traditional risk management process encourages a response, which involves, among others, a risk mitigation strategy (Crouhy, Galai et al. 2006). However, the assessment of risk in the Arctic sea regions is a challenging task, because the conditions are changing and there is a lack in incident statistics for calculating probabilities. There are variations of accidents, depending on ship and sailing patterns, and new accident types emerging, as shown in table 1. Grounding means that the ship hits land or an underwater rock. Damage due to collision includes both collision with other vessels/sea installations and sea ice. The category violence means incidents of violent behavior towards persons and physical installations, from environmentalists stopping activity to terror and piracy. The category other may include failure on the vessel such as construction and engine failure.

Table 1 Possible variations of accidents, depending on ship and event types

	Tourist	Cargo/tanker	Fishing
Grounding	T-G	C-G	F-G
Collision	T-C	C-C	F-C
Fire	T-F	C-F	F-F
Violent action	T-V	C-V	F-V
Other	T-O	C-O	F-O

The risk matrix approach has been widely used for initial discussions on preparedness improvement, because it provides a coarse-grained picture of risk levels as a basis for further assessments. They also serve as a platform for a discussion on priority needs both precautions and safety efforts, and allocation of preparedness resources. An example of such an assessment, The Polar code established by the International Maritime Organization (IMO) for the icy waters is a significant step towards reducing the probability of accidents through more robust vessels and improved training, and a step towards reducing consequences of an accident for better SAR preparedness on board the vessels.

The risk matrix approach, however, has its limitations (Cox Jr 2008). In general, risk matrices have limited ability to reproduce risk ratings accurately because of the difficulties involved in quantifying the two components of risk and their possible correlation. In most existing and available analyses, the risk level is difficult to assess because neither the probability nor the harm severity can be estimated with accuracy and precision (Cox Jr 2008). In particular, in Arctic waters, some accident types such as violent action and terror have not happened, so no statistics exist for calculation of such a probability.

The risk assessment that is based on low incident occurrence historically, may, in fact, be misleading. Such a traditional view suggests that one does not prepare for a certain crisis until it has already happened. Ian Mitroff (Mitroff 2004) claims that the "black swans", the crisis that an organization does not prepare for, may cause as serious harm as the ones we are prepared for. He suggests that for risk assessment in strategic decision-making, it is precisely those crises that have not occurred that need to be considered. As an example, the Polar code may be focusing on more issues and other sea areas as well if using this type of risk assessment approach.

Therefore, risk assessments in regions such as the Arctic should be based on a combination of quantitative and qualitative information. Categorizing severity may require inherently subjective judgements about consequences and decisions on how to aggregate multiple small events and fewer severe events. Therefore, risk matrixes require a subjective interpretation (Cox Jr 2008). Qualitative risk matrixes on emergency preparedness should be based on both the existing statistics and estimates from experts from professional and research emergency preparedness institutions.

Based on assessment of accidents and experiences from exercises, we claim that for better reliability, the following factors should be taken into account in addition to incident statistics:

- the density of maritime traffic
- the increased capacity of fishing vessels
- the increased interest in cruise shipping in remote areas
- the increased size of the cruise ships entering Arctic waters
- the increased number of Arctic expedition cruise vessels contracted

- the number of oil and gas exploration licenses given in the High North, especially in Norway and Russia
- differences in government and industry regulations across borders
- efforts from international organizations, governments and industries to increase safety in Arctic waters
- the availability of emergency capacities and their response time in different sea areas

As for categorization of consequences in case of a lack of statistics in the Arctic region, there is a need to learn from the largest SAR and oil spill response operations. Mitroff (Mitroff 2004) points out those such lessons from previous crises have too often been ignored, not learned. For this purpose, it is necessary to analyze past mishaps, on-scene drills and engage in realistic, full-scale exercises covering the different sea regions. There is also a need to distinguish between the risk of severe consequences for the environment and for humans. Consequences will always depend on different factors and preparedness, and resource availability is one of the most important ones.

5 METHODOLOGY

In this study, the risk matrices show 1) the frequency level of different types of incidents with different types of vessels and 2) the severity of consequences for human health and the environment. A certain element of qualitative expert evaluations on specific risk areas or defined situations of hazard and accident (DSHA) serve as the basis for the matrix. The estimation of consequences is based on case studies of the effects of real incidents in different parts of the world illuminating accidents with different types of vessels. The analyses are also based on results from exercises showing the capabilities of mitigating the negative effects of accidents in Arctic waters. For our assessment, we use the moderate scenario of the accidents as a base for judgement on consequences.

Data for analyses include published reports on maritime activity in the Arctic, facts published by emergency preparedness institutions on relevant issues in Norway, Iceland, Russia and Greenland/Denmark. In addition, risk assessments have been discussed with industry specialists, government officials, researchers, navigators, and representatives from SAR-related authorities, organizations and academic institutions. The qualitative data was collected and discussed at the MARPART advisory board and project group meetings.

MARITIME RISK IN THE ATLANTIC ARCTIC

Using developed algorithm (Marchenko, Borch et al. 2015) we have made a risk assessment and created the risk matrices for all five regions. We have estimated the risk for people and environment separately. The first risk matrices for Norway and Russia were published in (Marchenko et al., 2015, Marchenko et al., 2016), for Greenland and Iceland in (Marchenko et al., 2017). Here we perform improved matrices for humans for all five regions (Table 2-6). The probability of high-risk event types increase with growing activity level in the number of vessels, and the number of passengers and presence of dangerous goods on each vessel. An increased number of vessels may bring more sailors with limited experience in running a ship in this region. The remoteness of Arctic routes and the cold climate makes human life vulnerable if a crisis with a passenger vessel should occur, even with advanced rescue equipment (Solberg et al., 2016).

Table 2. Risk matrix for people in Greenlandic waters. Risk level: red - high, yellow –moderate green – low; Possibility of accidents 1- Theoretically possible, 2 – Very rare,3 – Occurs, 4 – Relatively frequently, 5 – Frequently; Consequences: A - Insignificant, B – Minor. C – Moderate, D – Significant, E – Serious

	A	B	C	D	E
5					
4					
3			T-G, C-G, F-G		
2	T-V, C-V, F-V, T-O, C-O, F-O	T-C, C-C, F-C	T-F, C-F, F-F		
1					

Table 3. Risk matrix for people in Icelandic waters. Legend and symbols see Table 2.

	A	B	C	D	E
5					
4					
3				F-G, F-C, F-F, C-F, T-G,	T-F
2				C-G, C-C, T-C, F-O, C-O, T-O	
1					F-V, C-V, T-V

Table 4. Risk matrix for people in Svalbard waters. Legend and symbols see Table 2.

	A	B	C	D	E
5					
4		F-G			
3		F-C		T-C,T-G	
2		F-O	C-O,C-C, T-O, C-G	F-F	T-F, C-F
1				F-V,C-V	T-V

Table 5. Risk matrix for people in Northern Norway waters. Legend and symbols see Table 2.

	A	B	C	D	E
5					
4			F-O	F-G	
3			C-G, C-O	C-F, F-F, F-C,C-C	T-C
2				T-G, T-O	T-F
1			F-V, C-V		T-V

Table 6. Risk matrix for people in the Russian Barents Sea. Legend and symbols see Table 2.

	A	B	C	D	E
5					
4		F-G, F-O			
3			T-G,C-C C-G	F-F, F-C,	
2			T-O	C-O, T-C	T-F, C-F
1				C-V, F-V	T-V

To assess the total risk and compare the regions, we estimated the share of events with different risk levels, taking 100% as the total amount of chosen events. In our case, there are 15 different types of events: three defined types of ship (tourist, cargo, and fishing) and five defined types of accidents (grounding, collision, fire, violence and others (f.ex. technical failure)). Analyzing the risk matrixes for the different regions, we counted the amount of event types on each risk level (Table 6). For example, for Russia, we emphasize four types of high-risk events for life and health – collision of fishing vessels, and fire on cargo, fishing and tourist vessels. For Svalbard, there are four other high-risk types for life and health – all types of events with tourist ships (collision, grounding, fire) as well as fire on cargo vessels. Large cruise ships are the main concern of the SAR authorities on Svalbard. There are no other places in the world where cruise liners with 3000 tourists on board run up to 80^{O}N. In case of an accident, there are limited resources to save people in distress. The nearest ship to help may be several hours away. Two Super Puma helicopters based in Longyearbyen are not enough for mass evacuation. As a specific Svalbard exercise (November 2015) showed, these two helicopters can evacuate 80 persons in seven hours operating from Longyearbyen 50 km (Svarstad 2015). One can compare this number with average cruise vessels with two thousand people on board in the Magdalena fjord (the main tourist attraction) on 180 km distance. Another case may be an exercise with expedition ships with 150 persons on board in the Hinlopen Strait on the same distance, but with much more low probability to have other ship nearby.

Hypothermia is the main issue in case of large disasters in a very remote place in the Arctic. Due to long distances, assistance cannot arrive soon, and most likely, in an emergency case, people will need to wait for several hours. In an exercise testing survival in lifeboats and life rafts in ice-infested waters, even the youngest and best-trained coast guard vessel crew faced problems after 24 hours in the life raft (Solberg, Gudmestad et al. 2016).

Among the larger accidents in the Arctic we find the cruise liner *Maxim Gorkiy* (holed by ice at 60 NM west of Svalbard, 1989) (Kvamstad, Bekkadal et al. 2009, Hovden 2014) and the *Hanseatic* (grounded in Murchinsonfjorden, 1997), (Lorentsen 1997). The last accident occurred in the summer of 2016 – a Cruise ship *Ortelius* with 146 people (105 passengers) had to be towed for 2 days from the Hinlopen strait north of Svalbard back to Longyearbyen after engine failure (Sabbatini 2016).

Table 7. Type of events of different risk level (red - high, yellow – moderate, green – low) for regions under consideration

Greenland	Iceland	Svalbard	Norway	Russia
RISK FOR PEOPLE				
	6 F-G, F-C F-F, C-F, T-G, T-F	4 T-C, T-G, T-F, C-F	8 F-O,F-G, C-F, F-F F-C,C-C, T-G, T-F	4 F-F, F-C T-F, C-F
6 T-G, C-G, F-G, T-F, C-F, F-F	9 C-G, C-C, T-C, F-O, C-O, T-O, F-V, C-V, T-V	10 F-G, F-C, T-O,C-O, C-C,C-G, F-F, F-V, C-V, T-V	5 C-G, C-O, T-G, T-O, T-V	11 F-G, F-O, T-G, C-C, C-G, T-C, T-O, C-O, C-V, F-V, T-V
9 T-V, C-V, F-V, T-O, C-O, F-O, T-C, C-C, F-C		1 F-O	2 F-V, C-V	
RISK FOR ENVIRONMENT				
			6 C-F, C-O, C-C, C-G, T-C, T-G	2 C-C, C-G
8 F-G, T-G, C-G, T-C, C-C, T-F, C-F, F-F	12 F-F, F-G, F-C, T-G, C-F, T-F, C-C, T-C, C-G, F-O, C-O, T-O	10 F-G, F-C, T-C, T-G, T-O, C-O, C-C, T-F, C-F, C-G,	7 F-G, F-F, F-O, F-C, T-F, T-O, T-V	11 F-G, F-O, F-F, T-G, F-C, T-O, C-V, C-F, T-F, C-O, T-C
7 T-V, C-V, F-V, T-O, C-O, F-O, F-C	3 F-V, T-V, C-V	5 F-O, F-F, F-V, C-V, T-V	2 F-V, C-V	2 F-V, T-V

In the more densely trafficked coastal region of Norway, we list eight types of high-risk level for life and health – accidents with fishing ships due to a large number of vessels and high activity in the winter months; fire and grounding of both cargo and tourist vessels, especially in the autumn and winter months. The fishing vessels represent the majority of vessels along the Norwegian coastline and are the dominating factor in the statistics of accidents at sea. This included the number of wounded and dead persons. For the first half of 2016, there were 123 persons wounded and four persons dead at sea. Three out of four deaths were at a fishing vessel.

Passenger vessels have experienced few incidents. However, the consequences may be significant. One example is the grounding of the fast passenger vessel *MV Sleipner* in 1999 where 19 persons died. The larger passenger vessels/cruise ships are represented in the grounding statistics. One example is the grounding of the cruise ship *MV Marco Polo* in the Lofoten Islands in 2014 with 1096 persons onboard. There are, however, few incidents in total and no subsequent examples of severe accidents due to groundings and collisions. Fire and other problems like engine failure is very critical along the Norwegian coastline and may lead to significant losses. The fishing fleet faces challenges in this respect quite frequently.

Engine and fire problems occur in the passenger fleet also. The coastal steamer *Hurtigruten* traveling the coast with many vessels all year round occasionally has been challenged with such incidents. . However, there are seldom severe accidents. One serious exception was the fire onboard Scandinavian Star in 1990 where 159 persons died out of 500 persons onboard. A more recent accident is the engine fire on board the Hurtigruten coastal steamer *Nordlys* in 2011, with 262 persons onboard. Two of the engine crew died and 16 persons were injured.

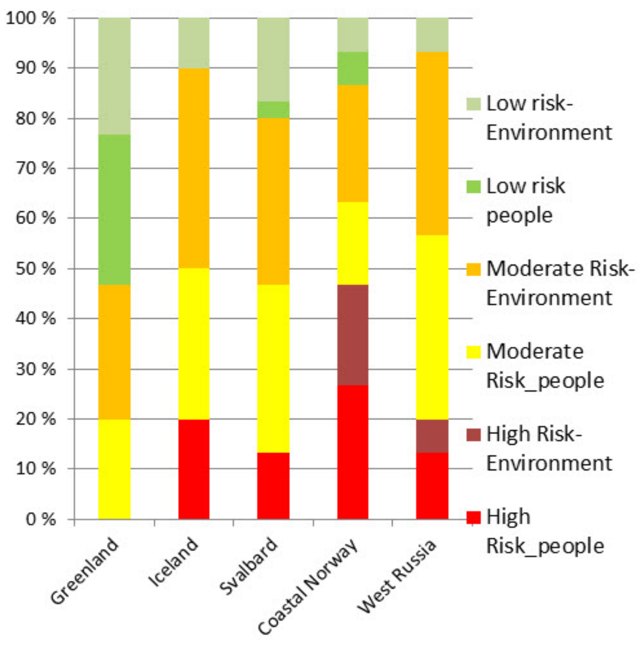
For Iceland, tourist vessel grounding is estimated as a high risk factor because of the consequences due to remoteness of the tourist routes from the nearest SAR-capacities. The ships that have grounded or collided in the sea around Iceland have generally been smaller fishing vessels and older cargo ships, which have not been sailing according to a regular schedule. Large cruise vessels have not grounded around Iceland, but there have been incidents with smaller passenger boats. Should an incident involve a larger vessel, it is obvious that the consequences could be very severe for the environment.

Until now, we have not experienced severe violent acts in the maritime Arctic. That is why all violence events are estimated as low risk due to a limited probability.

In general, regions with intensive traffic (coastal Norway, Western Russia) may see a higher probability. However, at least in the Norwegian coastal waters there is more rescue resources and a higher level of preparedness, which makes it easier to find other vessels to help near-by ships in distress. The cconsequences for the environment are, however, more severe closer to land, where pollution recovery is both difficult and time-consuming.

The estimates as to pollution may increase due to more traffic with dangerous goods from Russian oil and gas fields.

Table 8. Share of events with different risk level in the regions.



6 IMPLICATIONS FOR RESPONSE CAPACITIES

There are few assessments done emphasizing the future risk pattern and the subsequent need for emergency capacities in the Arctic. Risk assessments have implications for the development of emergency response capacities, including allocation of preparedness resources, development of rescue equipment, communication and navigation resources, as well as coordination capacities, which are, in fact, crucial in the context of scarce resources.

Priority needs should be discussed, primarily in regards to high-risk emergencies. Possible multiple events or crises that have not occurred must also be taken into consideration.

Tourist vessels fall into high-risk cells in the assessment matrixes, especially in case of fire incidents and groundings. This type of event may be very dynamic with escalating consequences as times go without sufficient capacities mobilized and brought on-scene.

Collision is a high-risk event for Svalbard and Coastal Norway, and grounding is a big concern for Iceland and coastal Norway. The main challenge for the preparedness system capacities for tourist vessels is managing response to a large amount of people, having enough rescue equipment and handling accidents that can happen in other country than the port of departure. The requirements for vessels, their activity and management procedures are important. As the cruise vessels, increase their traffic to the Arctic in autumn and winter months the challenges increases. Weather conditions, icing, drift ice and long distance from land can significantly hamper search and rescue operations, therefore enhancing rescue equipment suitable for cold climate and enforcing capacity during winter months are important for the Arctic regions.

Cargo vessels represent a risk as to fire in all studied regions, and in case of collision and grounding in coastal Norway. The region has also perceived especially grounding with cargo ships as high-risk events for the environment after several accidents along the coast such as the MV Server, Full City and Godafoss groundings. Russia considers the collision and grounding of cargo vessels as a high-risk event for the environment as well. With increased transport activity, especially related to the petroleum industry in these regions, it is necessary to reexamine the monitoring system of coastal sea traffic, and ensure cross-border partnerships, especially in border zones offshore and far in the north. It is important to create cooperation and frequent training with standby vessels from oil installations, helicopters and equipment, which can handle long distances, ice and icing. There is also a need for developing specialized oil spill recovery equipment for icy waters (ref. Norwegian White Paper 35 (2015-2016) "On the right course")

The high risk for fishing fleet is assessed in case of collision and fire in the regions with the increased fishing maritime activity – Russia, coastal Norway and Iceland. Grounding is a concern for Iceland and Norway. The high-risk emergencies with fishing vessels call for ensuring both towing and emergency helicopter capacities. The challenges related to fisheries in the Arctic will increase if the fishing fleet operate in a larger geographical area and farther north.

Uncommon and multiple accidents may demand an increased emergency resource capacity. Machinery damage may often cause fire; fire and collision of vessels may cause oil spill; grounding, fire, collision or violent action may cause serious injuries to people, etc. The riddle effect of the composite threats lies in their unexpected nature and highly complex coincidences due to the Arctic context. Therefore, the main challenge for emergency capacities remains with the coordination and the dynamic capabilities for fast reorganization of the available and suitable resources. The capacity efforts should be directed towards development of the joint emergency response system, improvement and sharing of emergency resources and advancing competences in emergency management in the Arctic seas. This calls for increased frequency and complexity level on joint exercises like the Exercise Barents. There is a need for full-scale exercises in remote areas and preferably in the autumn and wintertime, where the challenges are significantly higher than in the summer.

missing persons and oil pollution. Thus, a minor accident in this region may fast escalate into a disaster.

In the last decades, emergency preparedness resources in the Arctic have been significantly strengthened through the addition of available vessels and helicopters. However, still the response time may be long and the capacity limited if major incidents occur. This calls for increased research efforts to learn more about how to reduce the probability of unwanted incidents. This includes in-depth studies of modern vessel design and equipment, systems and procedures, as well as the education and training of key personnel. We also need to look closer into the preparedness capacities both for the private actors in the region as well as on the government side as to both technology and personnel. We need to look into the competences of both the vessel crew and the emergency response resources to deal with the Arctic water challenges. This includes research on training and exercise schemes on less likely large-scale incidents demanding efforts from a broad range of emergency response actors, and cross-border support from other nations where institutional dimensions may represent an extra factor.

7 CONCLUSION

In this paper, we have shown that the increased traffic of oil and gas tankers, passenger ships and fishing vessels in the Atlantic Arctic may lead to negative incidents with such large consequence that mitigation efforts from a broad range of resources are needed. Efforts to reduce probability are imminent in the new regulations for ice-infested waters, especially the Polar code. It is important that the operative standards following the Polar code such as navigation planning and polar water operation manuals are at a high enough safety level to reduce the probability of incidents, especially related to cruise vessels, Also, the risk assessments point to the need for emergency response plans, resource allocation and an organization of the preparedness system in an optimal way. This may also include strengthened cooperation across borders. In this study, we have, however, highlighted a significant risk in areas not covered by the Polar code. Thus, the Polar code should be developed further and linked to the specific challenges of all Arctic sea regions.

In this study, we have shown that the validation of the risk assessment tools is important. Effective risk management decisions cannot be based exclusively on mapping ordered categorical ratings of frequency and severity, as optimal resource allocation may depend crucially on other quantitative and qualitative information. Therefore, distinguishing between the most urgent and least urgent risks in a setting with fast changing conditions and the lack of incident statistics, like the Arctic sea regions, is a challenging task. There is a need to reflect on the sudden appearance of the "Black Swan" incidents. To prepare for the rare, but dramatic events, qualitative judgements and worst-case scenario analyses are needed. The non-expected accidents may bring a combination of accidents, such as fire, wounded and

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REFERENCES

Arctic Council (2011). Agreement on cooperation on aeronautical and maritime search and rescue in the Arctic. Nuuk, Greenland, Arctic Council.

Cox Jr, L. A. (2008). "What's Wrong with Risk Matrices?" Risk Analysis 28: 497-512.

Crouhy, M., D. Galai and R. Mark (2006). The essentials of risk management. USA, McGraw-Hill.

DNV GL (2014). Miljørisoko knyttet til potensiell akuttoljeforurensning fra shipstrafikk i havområdene omkring Svalbard og Jan Mayen: 58.

Hovden, S. T. (2014). 25 år siden Marsim Gorkij-ulikken. Svalbard Posted. Longyearbyen.

Joint Arctic Command (2016). Skibsfartens of luftfartens redningsråds årlige redegørelse for sø- og flyveredningdtjenesten i Grønland i 2015: 23.

Kvamstad, B., F. Bekkadal, K. E. Fjørtoft, B. Marchenko and A. V. Ervik (2009). A case study from an emergency operation in the Arctic Seas. Marine Navigation and Safety of Sea Transportation. Gdynia, Poland, CRC Press/Balkema, Taylor & Francis Group: 455-461.

Lorentsen, N. (1997). Fire døgn på skjæret. Svalbardposten. 28: 6-7.

Marchenko, N. A. (2015). Ship traffic in the Svalbard area and safety issues. The 23rd Int. Conf. on Port and Ocean Eng. under Arctic Conditions (POAC 2015). Trondheim: 11.

Marchenko, N. A., O. J. Borch, S. V. Markov and N. Andreassen (2015). Maritime activity in the High North – the range of unwanted incidents and risk patterns. The

23rd Int. Conf. on Port and Ocean Eng. under Arctic Conditions (POAC 2015). Trondheim.
Marchenko, N. A., O. J. Borch, S. V. Markov and N. Andreassen (2016). Maritime safety in the High North – risk and preparedness. 26th International Ocean and Polar Engineers conference (ISOPE-2016). Rhodes, Greece: ISBN 978-971-880653-; ISSN 881098-886189.
Marchenko, N. A., O. J. Borch, N. Andreassen, S.Y.Kuznetsova, V.Ingimundarson, U.Jakobsen (2017) Navigation Safety and Risk Assessment Challenges in the High North. *12th International Conference on Marine Navigation and Safety of Sea Transportation TransNav.* Gdynia, Poland: CRC Press, Taylor and Francis Group
Mitroff, I. I. (2004). Crisis Leadership. Planning for the Unthinkable., John Wiley &Sons Inc.,. USA., John Wiley &Sons Inc.
Nord Universitet. (2017). "MARPART -Maritime preparedness and International Collaboration in the High North." from www.marpart.no.
Norwegian Coastal Administration. (2017). ""Havbase" (Sea base)."
Sabbatini, M. (2016). Ship out of luck: Governor tows vessel with 146 people back to Longyearbyen after engine failure. Ice people. Longyearbyen.
Solberg, K. E., O. T. Gudmestad and B. O. Kvamme (2016). SARex Spitzbergen April 2016-search and rescue exercise conducted off North Spitzbergen, University of Stavanger. Report 58, 2016.
Svarstad, S. M. (2015). Øvelse Svalbard. National helseøvelse 2014. Største i historien på Svalbard.
Trbojevic, V. M. C., B.J (2000). "Risk based methodology for safety improvements in ports." Journal of Hazardous Materials 71: 467–480.