FoU-RAPPORT

Maritime activity and risk patterns in the High North

MARPART Project Report 2

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Summary: This report provides a discussion on dominating risk factors, risk types and the probability of unwanted incidents in the Arctic region. It also provides a coarse-grained evaluation of the potential consequences of different incidents in the northern sea areas of Russia, Norway, Greenland and Iceland. The risk assessments build upon statistics on vessel activity, case studies of real incidents, and expert evaluations of defined situations of hazard and accident (DSHA). The evaluations in this study may serve as a platform for more detailed assessments, and as input for discussions on priority areas in respect to safety measures and emergency preparedness. In the Marpart project, the risk assessments have a special role as input into the analyses of emergency management capabilities, and the need for special governance efforts in cross-border cooperation.	Keywords: Maritime activity Maritime risk factors Maritime incidents types and consequences Risk assessment

MARPART

INTERNATIONAL R&D PARTNERSHIP ON MARITIME SAFETY AND SECURITY IN THE HIGH NORTH

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Project partners:

- High North Center at Nord University Business School (Norway)
- Norwegian Defense University College (Norway)
- Norwegian Police University College (Norway)
- UIT-the Arctic University of Norway (Norway)
- University Center in Svalbard (Norway)
- University of Greenland (Greenland)
- University of Iceland (Iceland)
- Northern (Arctic) Federal University (Russia)
- Murmansk State Technical University (Russia)

THE MARPART RESEARCH CONSORTIUM

The management, organization and governance of cross-border collaboration on emergency operations in the High North

The key purpose of the Marpart research consortium is to increase understanding of the emergency management challenges in large-scale emergencies in the Arctic sea areas. We start with an assessment of the risk related to different types of maritime activity in the High North and the implications for the preparedness institutions in this region. We focus on cross-institutional and cross-country partnerships between preparedness institutions as well as private companies in the Arctic region. We elaborate on the operational crisis management of joint emergency operations including several parts of the preparedness system and resources from several countries.

We emphasize the responsibility of the governments as to safety, security and environmental protection in the High North. Maritime preparedness is defined as the system for damage avoidance and reduction related to unexpected and unwanted incidents at sea. We elaborate on the need for enhanced measures to respond to composite challenges including search and rescue (SAR), oil spill recovery, firefighting and salvage, and actions against terror or other forms of destructive action. To increase both effectiveness and efficiency within the preparedness system, we are in need of management tools for coordination and control making optimal use of the joint resources of several institutions both within and between countries.

In this project, we take as a starting point the commercial activity in the High North and the vulnerability related to human safety, environment, and physical installations/vessels. The commercial activity in the High North includes intra- / interregional transportation, search for and exploitation of petroleum and mineral resources, fisheries, and cruise tourism. Limited infrastructure, low temperatures with ice and icing, polar lows, and a vulnerable nature, challenge maritime operations in this region.

MARPART project goals:

- To increase understanding of future needs for joint operations within a preparedness system in the High North including both search and rescue, oil spill recovery, firefighting and salvage, and actions against terror or other forms of destructive action;
- To provide analytical concepts for studying coordination challenges in cross-border, multi-tasking operations;
- To contribute with organizational concepts for inter-organizational partnership and management of joint operations.

Cross-disciplinary, international research network consists of twenty professors/researchers and PhD-students. 18 universities, police and naval academies and research institutes from eight countries (Norway, Russia, Iceland, Greenland, Denmark, Sweden are now part of the Marpart network. In addition universities from Canada, USA, and Finland are part of an extended academic network called UArctic thematic network on Arctic Safety and Security. The project partners have established Advisory Boards in each country including government preparedness authorities and industry representatives.

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This report also relies upon the expertise of the different actors operating and analyzing the preparedness system in the participating countries. We are particularly thankful for input and support from: The Norwegian Coastal Administration; Resources and Competence Center for Safety and Preparedness in the Northern Region; High North Center at Nord University Business School; Salten Regional Police Department; Maritime Forum of Northern Norway; Joint Rescue Coordination Center Northern Norway; the Preparedness Department of the Nordland County Governor; Nordland County Administration; Norwegian Directorate for Civil Protection; The Petroleum Safety Authority Norway; Norwegian Coast Guard; Icelandic Coast Guard; the Environment Agency of Iceland; and the Department of Civil Protection and Emergency Management at the National Commissioner of the Icelandic Police; Maritime Rescue Coordination Center of Murmansk (Russia); Arkhangelsk Regional Rescue Service (Russia); Arkhangelsk Regional Agency for State Fire Service and Civil Protection (Russia).

EXECUTIVE SUMMARY

This report provides a discussion on dominating risk factors, risk types and the probability of unwanted incidents in the Arctic region. It also provides a coarse-grained evaluation of the potential consequences of different incidents in the northern sea areas of Russia, Norway, Greenland and Iceland. The risk assessments build upon statistics on vessel activity, case studies of real incidents, and expert evaluations of defined situations of hazard and accident (DSHA). The evaluations in this study may serve as a platform for more detailed assessments, and as input for discussions on priority areas in respect to safety measures and emergency preparedness. In the Marpart project, the risk assessments have a special role as input into the analyses of emergency management capabilities, and the need for special governance efforts in cross-border cooperation.

Russia: The traffic in Arctic Russia predominately consists of internal traffic between Arctic harbors and an increasing volume of transit traffic related to LNG and oil transport from terminals in northwestern Russia. Potential risk factors for the maritime activities in the Russian Arctic are the severe climatic conditions, the presence of sea ice, and technical risks related to vessels. A new pattern of activity is emerging as explorer cruise vessels are searching for new summer cruise routes in Arctic Russia.

The risk assessment shows that the probability of accidents is low, but the consequences may be severe due to the presence of ice and other cold climate conditions, along with institutional factors such as remoteness and lack of preparedness infrastructure. The highest environmental risks concern the potential for fires on-board the vessels and collisions with ice. The highest potential for loss of life concerns the potential for fires, grounding and collisions with the ice for tourist ships and fishing vessels, along with the grounding and collision of cargo ships. The risks related to both grounding and collision with ice are significantly high in the winter months. However, the numbers of ships are limited, and the vessels have high ice class and/or are escorted by icebreakers. When it comes to the risk of violent actions, including terrorism, the probability is very low. The consequences may, however, be significant due to distances for medevac helicopters, police and special forces, with weather conditions such as fog hampering personnel transport.

In general, the skills level of the Russian participants in maritime activity complies with international standards. The fleet is being modernized, but there are still many old vessels, especially in the fishing fleet. The search and rescue fleet has received major state investments and is currently receiving several advanced rescue vessels of different types. To prepare for future challenges related to the possible growth of maritime activity in the Arctic, there is a need to further develop technologies, routines and rescue procedures to reduce the probability of accidents, and to improve personnel training as the first-line emergency response capacity. Special attention should be paid to the monitoring of staff health to prevent diseases at sea, safety management during works and navigation operations, and to improve the competence of crews and the personal responsibility of every seafarer. There is a need to test and develop emergency responses in teams for different types of incident including oil spills, collisions, groundings, fires, and even large-scale violent action and terrorism.

Norway: The risk factors raising the likelihood of accidents in the Norwegian waters and sea areas around Svalbard include operations in narrow fjords and straits, poorly charted waters and remoteness, ice and icing in the Northern part of the Barents Sea and the Svalbard region, cold and unpredictable weather, and darkness in wintertime. Seasonal variations in conditions should be considered and special precautions taken according to area and time of year. Special risk assessments should be performed by the government and the ship owners operating in remote areas, and especially operations during the autumn and winter season. Lack of experience in these waters, vessel capacity and crew fatigue are risk-shaping factors. In the Svalbard region, these stressors are exacerbated and increase the likelihood of an accident. The limited capacities for mitigating the consequences of large-scale accidents in the outer islands, and in the Svalbard region in particular, imply that the consequences may be more severe for cruise ship passengers. Precautions within the industry and an increased focus on preparedness capacities in local and central government in the case of mass-rescue operations should be highlighted.

Along the coast of mainland Norway, there are changes in the traffic pattern of vessels connected to offshore service transportation to and from oil and gas fields, along with the transport of petroleum and minerals and within the fisheries. The changes in activity pattern call for continuous assessments of risk levels. The coastal sea traffic in Norway includes passenger and cargo transport dependent on the commercial activity level in the region. The predominant all-year traffic includes fishing vessels, general cargo ships and tankers. The frequency of SAR incidents is somewhat high within the fishing fleet due to its numbers, all-year operation in harsh weather, and operations close to the shore line. Moreover, they are operating close to the ice ridge in the Svalbard region. The cargo ships along the coast represent a special risk for oil spills due to groundings, and several severe incidents have occurred in the last few years. In the Svalbard region, larger cruise ships represent an environmental threat due to the large amount of fuel and especially heavy fuel oil on board. A ban on heavy fuel oil in the larger part of the Svalbard region reduces the risk of severe pollution. The fishing vessels in the region dominate by numbers, length and remoteness of operation. The statistics show that the majority of incidents take place in coastal sea areas close to the mainland of Northern Norway. However, the Svalbard region represents an area where incidents with fishing vessels are frequent, often resulting in the need for medevac and salvage.

Iceland: The main vulnerabilities for maritime traffic in the sea around Iceland concern bad weather conditions, ships' condition and equipment, the risk of fire, and risk of human error in decision-making. The enormous Search and Rescue Region (SRR) of Iceland – which is 19 times the size of the country itself – presents challenges for the preparedness system. Higher temperatures resulting from climate change have, for example, led to increasing drift ice, which can cause severe accidents and human and environmental threats. With the lack of infrastructure, conditions for rescue operations are very difficult north of Iceland and in the Greenland Sea.

The aging fleet of cargo vessels and tankers also poses a risk to the lives of crewmembers and rescuers and to the environment. While large cruise vessels have not grounded around Iceland, there have been incidents with smaller passenger boats. In the event of a ferry or cruise vessel accident, it could take days to transport people to land by helicopter and lifeboat. The risk of fire is present for all vessels and can pose a minor to moderate threat to the environment if it leads to an explosion or oil spill. While fishing vessels make up the largest part of maritime traffic in the sea around Iceland, the number of fatal accidents at sea has decreased drastically in the past decades. In regard to illegal activities, several drug smuggling attempts have been prevented in Iceland's Exclusive Economic Zone

(EEZ). No incidents of terrorism have been reported in the Icelandic SRR, but such violence remains theoretically possible; primarily for passenger ships and – less likely – cargo vessels. Whale hunting boats, in contrast, might be a more likely target for sabotage.

The Icelandic preparedness system and its response mechanisms do not face major problems. The Icelandic Coast Guard has, however, not been able to realize the full potential of its operational resources because it has been forced to curtail its monitoring functions due to budgetary restraints. While improved technology has simplified surveillance and rescue operations, the preparedness agencies have also been faced with new challenges, such as the increasing international nature of the shipping industry. Key governmental institutions still lack the legal power to take all measures considered necessary to prevent marine pollution and to ensure a full refund of the salvage operations. Finally, given the size of Iceland's SRR and the country's geographical distance, regional exercises and transnational operational cooperation are considered essential to improve responses to incidents.

Greenland: The main factors challenging the current SAR service and pollution response in Greenland are the enormous sea and land area that is within Greenland's area of responsibility. There are also challenges posed by the natural conditions with unpredictable weather, including frequent fog conditions, icebergs, and ice floes. Transport infrastructure is scarce, including a limited number of harbors. The helicopters and SAR resources are generally on the southwest and midwest coasts of Greenland and do not offer a fast and efficient emergency response in all areas of Greenland.

The types of vessel most commonly in distress and in need of SAR operations are dinghies, smaller motor boats and fishing vessels. These types of vessel have a limited number of people on-board.

Since 2009, the number of cruises in Greenlandic waters has risen by 14%. More maritime traffic and activity in the Greenlandic waters can also be expected due to the effects of climate change, with longer sailing seasons and wider sailing opportunities. The Greenlandic emergency response therefore needs the resources and capacity to handle both smaller SAR operations that only require Greenlandic SAR preparedness and OSR resources, yet also larger operations that need assistance from Denmark, Svalbard and probably Canada or Iceland as well, depending on the position and the size of a potential accident.

A significant risk for human lives and the environment is predicted for tourist and cruise ships that sail in remote and isolated areas. In regard to cargo vessels, tankers, tugs, international transport, passenger transport, petroleum activities and research vessels, the risk of an accident in a position far from the nearest harbor, heliport, medical service or environmental response is estimated to be rare and the consequences to be moderate due to the frequent use of qualified and Greenlandic navigators. The estimated level of environmental risk for fishing vessels or smaller motor boats is lower since these types of vessel are carrying less oil or diesel compared to larger types of vessel.

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INTRODUCTION

BY NATALIA ANDREASSEN AND ODD JARL BORCH

This report gives an overview of the risk patterns and types of maritime incidents in the High North that may appear threating life, environment and society values. The geographical focus of this overview is the sea area north of the Arctic Circle from the Kara Sea, along the Northwest coast of Russia, the Northern coast of Norway and around Svalbard, the Iceland sea area and the Greenland sea area. Developing commercial activities in the High North may increase the possibility of unwanted incidents. The vulnerability related to human safety and environment and a challenging context, calls for a continuous focus on safety issues and the capabilities of the maritime preparedness system.

This report pays attention to the dominating risk factors that may lay the premises for the configuration of the emergency preparedness system and commercial activity in sea areas in the High North. The dominating risk factors are categorized into weather conditions, vessels type and size, human errors and decision-making, risk of fire, grounding, collision, oil spill, violence and terror.

We build upon real accident experiences, experiences from exercises, experts perceived situations of hazards and statistics to examine the activities and the probability of incidents in different sea areas. Moreover, the consequences of potential damages and threats for human lives and environment are illuminated.

First, we reveal the complexity of the High North context for maritime operations with all its risk factors, stressors, types and sizes of vessels. Then we analyze the frequency of incidents and significance of consequences, providing risk assessment matrixes for each sea region.

METHODOLOGY

The assessment of risk is a challenging task especially when conditions are changing and we lack statistics for calculating probabilities. To illuminate the risk aspects in this study we present risk matrixes for the different sea areas. Our aim is to provide a coarse-grained picture of risk levels as a basis for further assessments and for a discussion on priority needs both as to precautions and safety efforts, and allocation of preparedness resources.

In the risk matrixes, we estimate 1) the frequency level of different types of incidents with different types of vessels and 2) the severity of consequences for a) human health and b) the environment. A certain element of expert evaluations on specific risk areas or defined situations of hazard and accident (DSHA) serve as basis for the matrix. The estimates on consequences is based on case studies of real incidents in different parts of the world illuminating accidents with different types of vessels. We also base the analyses on results from exercises on mitigating the negative effects of accidents in Arctic waters.

Table 1 shows the categorizations used in this study.

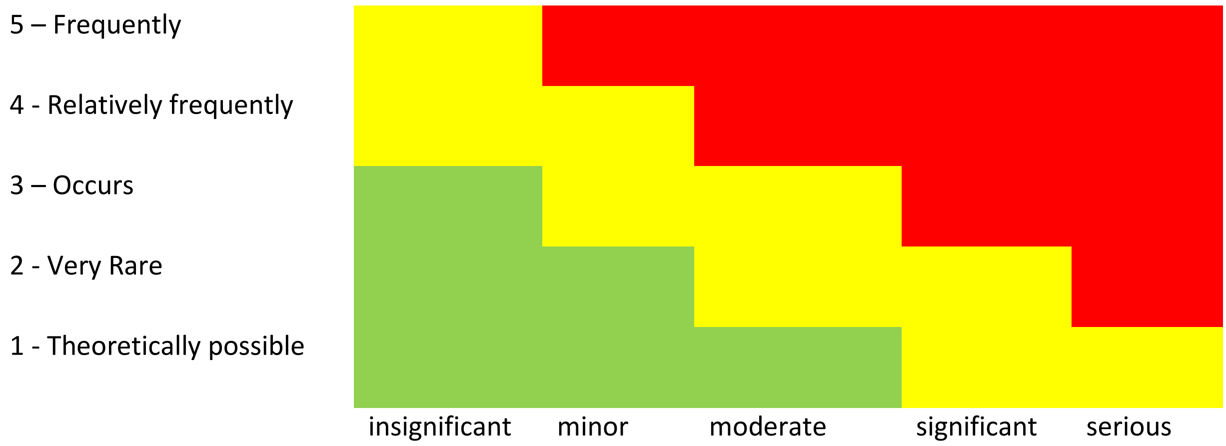
TABLE 1 POSSIBLE VARIATIONS OF ACCIDENTS, DEPENDING ON SHIP AND EVENT TYPES

	Tourist/Cruise ship	Cargo/tanker/petroleum Rigs/floaters	Fishing
Grounding	T-G	C-G	F-G
Damage due to collision (sea ice and other)	T-I	C-I	F-I
Fire	T-F	C-F	F-F
Violence/terror	T-V	C-V	F-V
Other reasons	T-O	C-O	F-O

Grounding means the ship hits land or underwater rock. Damage due to collision includes both collision with other vessels/sea installations and sea ice. The category fire is about fire breaking out on board. The category violence means incidents of violent behavior towards persons and physical installations. The category other may include construction failure.

Considering a risk as the amount of harm that can be expected to occur during a given time period due to a specific event, one can give indications on the level of risk. The risk is then the product of the probability that an accident happens multiplied by the severity of that harm. On a standard risk matrix red cells indicate high risk, yellow – modern, green – low (Table 2).

TABLE 2 A STANDARD RISK MATRIX



The risk matrix approach has been widely used for initial discussions on preparedness improvement, but has its limitations (Cox Jr, 2008). In most existing and available analyses, the risk level is usually given a coarse-grained categorization, because neither the probability nor the harm severity can be estimated with accuracy and precision. Moreover, some accident types such as violent action and terror have not happened in the High North waters so no statistics exist for calculation of probability, and we have limited understanding of possible consequences in this area. The main limitations of the existing risk assessments refer to the statistically assessed information about unknown quantitative risks that influences the ability of the matrix to provide priority guidelines for the different risk categories. In other words, categorizing frequency may require quantitative and qualitative information other than statistics, such as possible interactions among risks and countermeasures. Categorizing severity may require inherently subjective judgements about consequences and decisions how to aggregate together multiple small events and fewer severe events. Therefore, risk matrixes require subjective interpretation.

The method of qualitative risk matrixes, which the MARPART research consortium applies, is based on both the existing statistics and estimates from experts from professional and research emergency preparedness institutions. For the risk assessment analysis, published analytical reports on maritime activity in the High North, facts published by different official sources in brochures and on websites in Norway, Iceland, Russia and Greenland, and information from emergency preparedness institutions on relevant issues are used. In addition, risk assessments have been discussed with different specialists: industry specialists, government officials, researchers, navigators, and representatives from SAR-related authorities, organizations and academic institutions from Norway, Iceland, Denmark, Russia and Greenland. This includes the MARPART advisory board and project group meetings April 10, 2015, in Murmansk, Russia; the MARPART advisory board and project group meeting and conference February 25-26, 2016, in Reykjavik, Iceland; and the MARPART project conference 17-18 October 2016 on the Hurtigruten from Bodo, Norway. The theoretical underpinnings for the method were discussed during the 23rd International Conference on Port and Ocean Engineering under Arctic Conditions (POAC) held June 14-18, 2015 in Trondheim, Norway, and the 26th International Ocean and Polar Engineering (ISOPE) Conference held June 26-July 1, 2016 in Rhodes, Greece.

For better reliability of the risk matrixes presented in this report, the following factors influencing categorization into the future should be taken into account in addition to the incident statistics:

- the estimated level of future activity due to ice reduction and more usage of Arctic routes for transportation,
- 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,
- efforts from international organizations, governments and industries to increase safety in Arctic waters.

As for categorization of consequences, firstly, in case of a lack of statistics in the High North region, there is a need to learn from the largest SAR and oil spill response operations experienced. Secondly, there is a need to distinguish the risk of consequences for the environment and for people. Consequences will always depend on different factors and preparedness and resources availability is one of the most important ones.

Summing up, the MARPART risk matrixes differ from similar risk assessments on the following dimensions:

1. not only accident and spill accident frequency is calculated, but also the estimated activity in the High North sea areas;
2. consequences are categorized into two probability areas – for people and for environment;
3. consequences of large incidents are analyzed, even the cases without significant damage due to fortunately good conditions;
4. we include real cases from non-Arctic areas to better assess the consequences of an accident.

During the last decades, there have been significant increases in the emergency preparedness resources of the High North, among others with improved vessel and helicopter availability. Still the response time may be long and the capacity limited if major incidents occur. There is a need to analyze and estimate the activity level and the probability of incidents, the consequences of different incidents and assessing the risk engaged, in order to address risk levels and possible implications for the preparedness system in the High North. This may increase the opportunity to set the objectives, plans for necessary capacity, allocate resources and organize the preparedness system in an optimal way.

PART I Maritime Activity Risk Patterns and Types of Unwanted Incidents. The Russian Sea areas in the North-West Arctic *by Iurii I. Udin, Sergey O. Petrov, Sergey V. Markov and Svetlana Kuznetsova*

Growing exploration of the Arctic has triggered a number of concerns about safety issues. To overcome the safety challenges we need to take into consideration existing risk factors, such as harsh climate conditions, weather, ice conditions, wave and wind patterns, bad visibility, and human influence of Arctic conditions on human physiology and psychology). In addition, technological aspects such as electronic communication challenges, material tiredness, accuracy of hydrographic and meteorological data are of importance.

The development of Arctic oil and gas exploration, access to other natural resources, fisheries, transportation traffic, commercial and touristic shipping in the Arctic seas require measures to ensure safety for people, environment and equipment alongside the maritime activities. Therefore, we need to assess the risk levels and probability of various type of incidents. This may lead to damage prevention, better planning, and to establish an adequate preparedness system. Due to the context complexity, the cross-institutional and international cooperation might facilitate the SAR and oil spill response operations and increase the efficiency of such an actions.

The considerable distances and geographical vastness of the area require larger investments in emergency preparedness infrastructure along the coast to reduce response time and increase efficiency of rescue operations. In order to address this issue new rescue coordination centers are built on the Russian coast (in Murmansk, Archangelsk, etc), in connection with the new Arctic ports (Sabetta, etc.).

In this report, we will focus on the Russian Seas areas of the North-West Arctic comprising the Barents Sea, the White Sea and the Kara Sea. In the following chapter, we present four topics, Dominating risk factors, Activity and probability of incidents, Consequences of accidents and, Risk assessment.

1 DOMINATING RISK FACTORS

The Arctic Zone largely distinguishes itself from the rest of the Russian regions in terms of natural, economic and demographic setting. It is described as; extreme natural and climatic conditions with permanent ice cover and drift ice in the Arctic Ocean, patchy development of territorial economy, low population density (1-2 per 10 km^2), remoteness from major industrial hubs, resource intensive by nature of industries and sustenance systems. These are dependent on the supply of fuel, food and essential goods by other Russian regions, vulnerability of natural ecosystems to man-made disasters and economic activity (Chupriyan, 2013).

When assessing risk, an important condition is the precise definition of the relationship of factors affecting the development of the incident. All risk factors may either reduce or increase the risk of an emergency situation. Generally risk is defined as the product of the probability of an incident and the consequence of that incident (Risk = Probability x Consequence). Particularly the consequences of accidents - in terms of lives loss, environmental damage and/ or economical loss – may be more severe in the Arctic due to following conditions:

• Remoteness, huge distances, and lack of infrastructure;

• Darkness, which makes response more difficult;

• Extreme temperatures and weather that makes response more challenging;

• Sea ice complicating rescue operations and oil spill response;

• Vulnerable marine and coastal environment;

• Potentially long downtime of operations after accidents, due to only seasonal access for repair;

• High public attention to activities in the Barents Sea, low public tolerance for accidents, with

potential for loss of reputation for all parties involved (Barents 2020, 2013).

The current state of social and economic development of the Arctic zone of the Russian Federation is characterized by the following risks and threats:

TABLE 3 RISKS AND THREATS OF THE SOCIAL AND ECONOMIC DEVELOPMENT OF THE ARCTIC ZONE OF THE RUSSIAN FEDERATION

Social scope	Economic scope
• negative demographic trend in most of the Arctic regions of the Russian Federation, the outflow of labor forces (especially skilled ones) to the southern regions of Russia and abroad; • lack of social services network correspondence to the type and dynamic of the land settlement including education, health, culture, physical education and sport; • critical state of housing and communal services, inadequate supply of clean drinking water; • lack of labor forces effective training, the imbalance between supply and demand of labor forces (shortage of workers and engineer professionals and a surplus of unneeded occupations, as well as people with no vocational training); • poor life quality of the indigenous peoples of the North, Siberia and Far East of the Russian Federation living in the Arctic zone of the Russian Federation.	• lack of Russian modern equipment and technologies for exploration and development of offshore hydrocarbon fields in the Arctic; • depreciation of fixed assets, in particular, of transport, industrial and energy infrastructure • underdevelopment of basic transport infrastructure, its marine and continental components, aging icebreaker fleet, lack of small aircraft; • high energy consumption and low efficiency by the extraction of natural resources, high costs of production in the northern areas without effective compensatory mechanism, low labor productivity; • imbalance in economic development between the individual arctic territories and regions, a significant gap between the leading and depressed areas in terms of development; • insufficient development of navigation and hydrographic and meteorological support of navigation; • lack of the energy system development, and the irrational structure of generating capacity, high cost of electricity generation and transportation; • lack of modern information and telecommunications infrastructure that permits the provision of services to the population and economic entities across the Arctic zone of the Russian Federation; • lack of a comprehensive permanent space monitoring of the Arctic territories and water areas, dependence on foreign sources of funds and information management of all activities in the Arctic (including interaction with aircraft and vessels).

In addition to social and economic risk factors, there are scarce technical resources and technological capabilities in the field of science and technology for research, development and use of the Arctic areas and resources. The technical stress factors include the variety of operating conditions affecting the safe navigation. This is the age of maintenance of the fleet and its compliance with the circumstances of shipping in polar conditions, the quality and quantity of hydrographic navigation information, the adequacy and timeliness of hydro-meteorological services, the implementation technology of shipping activities and operations, including emergency situations, including shipwrecks and oil spills. These factors are difficult to quantify. Many of them considered by the Polar code.

Technical risks can especially be dangerous in extremely low temperatures. Most of the ships in this region have an age of more than 10 years. The fishing fleet is especially old and worn out (Shestakov, 2015). Most vessels have more than 20 years maintenance period.

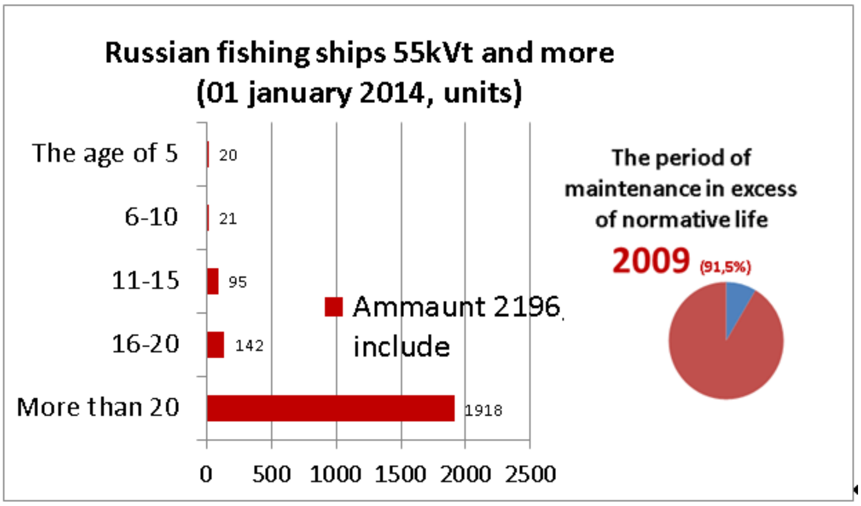


FIGURE 1 RUSSIAN FISHING SHIPS

Source. K.Ivanova, 2015a

Risk factors relevant for the Russian Atlantic sector from the Barents Sea to the Kara Sea include increased traffic through the Northern Sea Route, and emerging cruise ship traffic in the Russian part of the Barents Sea. Over the last 10 years, the coastal cargo transport has increased from 23% to 31%. There is a reorientation of a considerable part of cargo vessels from large-tonnage vessels of unlimited sailing to smaller ships of river-sea navigation and coastal vessels. According to statistics, the majority of accidents and the largest accidents (i.e. self-propelled pontoon “Varnek”, M/V “Victor

Koryakin," M/V "Sergey Kuznetsov" and the boat "Barents 1100") have occurred with such type of ships (Marchenko, 2015).

The number of Arctic cruises is low, however, cruising is increasing into the harbors of Murmansk and Arkhangelsk. It is relevant to note that the age of tourists may be an additional risk factor. Every third tourist is in the age of 70 to 90 years. Given the mobility of people of this age, it is necessary to ensure additional safety measures.

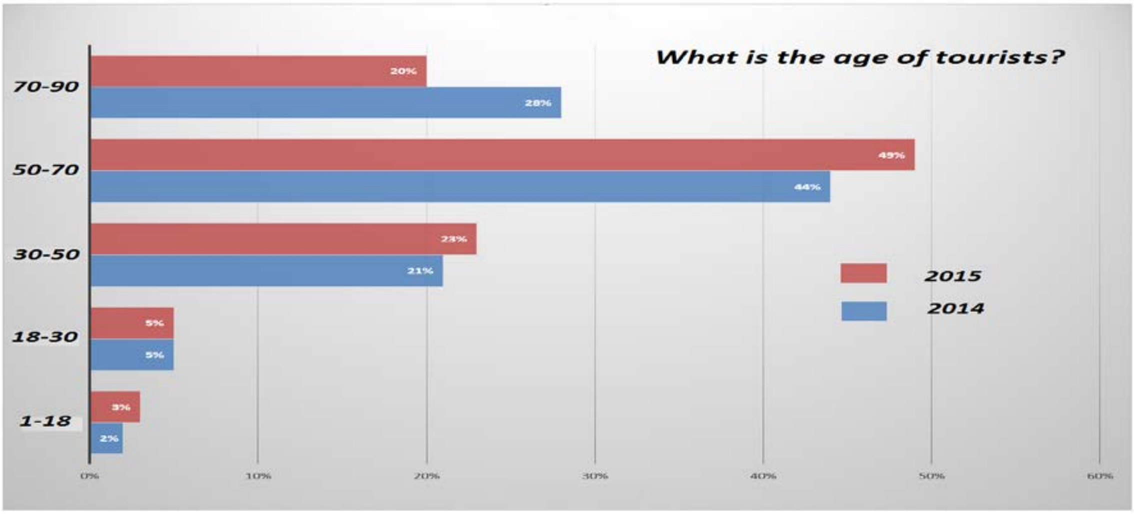


FIGURE 2 AGE OF TOURISTS VISITING THE ARCHIPELAGO OF FRANZ JOSEF LAND IN 2014 AND 2015

Source: http://www.rus-arc.ru

For the Arctic Russia the main weather stressors that impact on emergency response are: permafrost melting; ice jams and ice motion; snowstorms; massive storms, strong winds and ice slick. The global warming that Russia is currently experiencing, like other Arctic countries, brings to the foreground the effects of shrinking permafrost, a process affecting a huge part of Russia. In High North areas, these effects may pose a huge danger to human health and safety. For the northern areas, the climate change will mean an increased risk of flooding, a phenomenon known to outrank all other natural disasters in terms of average annual damage. The area will most likely see more frequent occurrence of hazardous processes such as landslide (as an immediate result of permafrost melting); slow thawed soil creep (solifluction); and formation of depressions due to ice melting and removal by melt waters of soil (thermokarst). All these processes are likely to affect not only the regional economy but also the entire emergency response system. They will also render the existing northern field aerodromes, which receive foodstuffs, mail, lubricants and other essential products used for rescue purposes that will be unsuitable for further use. The northern areas are facing the need to adjust their transport infrastructures to the impacts of climate change. The anthropogenic emergency-causing hazards include nuclear power plants and marine propulsion reactors; oil and gas pipeline ruptures; oil/gas spills and combustion; accidents in hydrocarbon production/metal processing/power generation/housing and utility sectors; shipwreck; rail/motor/aviation accidents.

The passage along the Northern sea route include natural phenomena such as icebergs, stamukhas (ice ridges) and ice rivers (Marchenko et al., 2015). Calving from icebergs occurs periodically and per calving event a large iceberg, 13,9 particles between 5 and 20 m are produced. These pieces pose large threats to the ship operating nearby. Studies on bergy bits and growlers show an impact with ice pieces in a various range of ship speed, result in high impact loads on the vessel. Small ice pieces can cause extensive damages to the vessel if the vessel speed is not reduced (Høvik, 2015). Therefore, the icebreaker fleet becomes important for safety in these waters. Russian icebreakers assist cargo and passenger vessels and military ships when crossing the ice on the Northern Sea Route, and provide safe Arctic tourism.

The human risk factors are related to the professional competence of crews of vessels and managers of fleet maintenance, the health of seafarers, responsible attitude of each crew member to their functions and duties. These factors increase their influence under the conditions. The crew must be prepared to shipping in these navigation conditions. The skill level of the Russian crews on the ships operating in Polar Waters complies with international standards adopted by IMO. All necessary measures of accident awareness are a basic part of maritime education. For example, in Murmansk State Technical University, Crews regularly take safety courses as a part of their pre-contract training and regular safety drills are carried out on board [www.mstu.edu.ru]. Nevertheless, the human factor prevails as the main reason for accidents (Davydenko, 2015). Among other human stressors that should be taken into consideration in the Arctic is the influence of Arctic conditions on humans – higher stress levels, longer periods without sunlight, atmospheric pressure, and how it influences safe operations at sea. This is an important and complex issue that requires further research (Chupriyan, 2013).

The self-propelled pontoon “Varnek” sailed from Arkhangelsk on 21 July 2010 with 17 cargo containers and other goods amounting to 130 tons in total. It was lost in a storm on 23 July. It was assumed that the captain looked for refuge from the storm to the North of Kanin Nos Peninsula. The ship owner tried to search for the “Varnek” himself, and only 61 hours after the disappearance of the “Varnek” he asked for help from the EMERCOM of Russia. In the second half of the same day, the rescue helicopter discovered the loss of a ship near the island of Korga. Nine people died (Khimanych, 2010).

Data published by ship owners and crewing agencies provided evidence that the most effective age of seafarers is in between 30 and 50 years of life. The navigators and marine engineers of this age already have enough experience on ships. They have a good health and they are in demand on the labor market. Generally, the vacant positions exceed the number of the specialists. Normally, sailors prefer ships that are just built up to 5 years of technical operation, or as a second preference - from 5 to 15 years. Ordinary positions on these ships take novice sailors aged from 20 to 30 years. But, the number of these is not large. On vessels from 15 to 25 years of operation, personnel is 25 years and older, formed by young seafarers from 20 to 30 years, and people over 50 years old.

Specialists these age categories are at risk. Young seafarers due to lack of experience, and more experienced sailors over the age of 50 due to possible professional burnout or weaker health. These points are overlaid with the technical factors associated with the operation of ships older than 25 years.

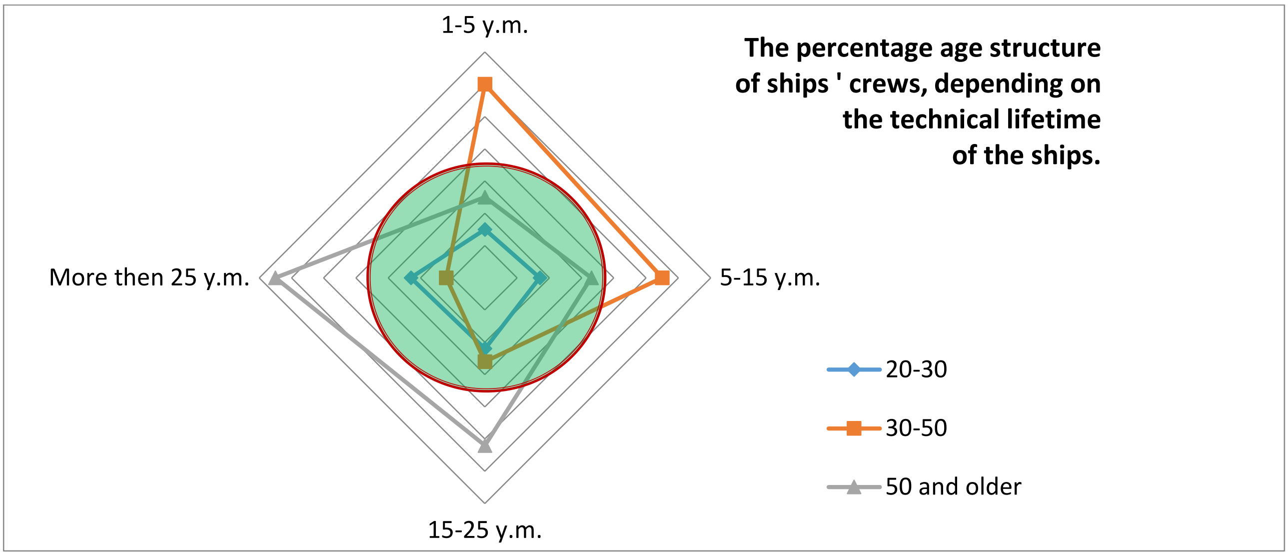


FIGURE 3 CHART OF CORRELATION OF AGE OF CREW MEMBERS TO THE PERIOD OF TECHNICAL EXPLOITATION OF THE VESSEL

The institutional risk factors are ones of the most important influencing risk assessment. Quantification extremely difficult. Its implementation is only possible on the basis of long statistical observations. From the institutional organization directly depends on the strategy and efficiency in decision making. Due to the significance of distances in the Arctic and the aggressiveness of the external environment, the time of arrival of rescue and its quality has a decisive importance in saving human lives and preserving the environment.

Going east, the distances to nearest adequate infrastructure increases. Ensuring the safety of maritime activities is difficult due to the considerable distances to harbors, airports and hospitals, as well as difficult ice conditions. Limited infrastructure in this region makes it difficult to face accidents with the necessary resources, also included within the preparedness system (Marchenko et al., 2015). An impact on the environment most likely exceeds the sustainable limits in certain regions of the Arctic zone of the Russian Federation, especially in the coastal regions [Development strategy of the Arctic zone]. Therefore it is necessary to highlight also the impact on the environment that may bring restricting laws and regulation.

2 ACTIVITY AND PROBABILITY OF INCIDENTS

The Russian Arctic has the thickest 'layer' of industrial activity; and the scale of industrial activity here is larger than that of the other Arctic states. Here we have the most urbanized Arctic community in the world, the maximum amount of monoprofile cities and settlements, and powerful resource sector of the Arctic economy (Pelyasov, 2013). The Russian Arctic is therefore vulnerable to accidents. An accident can be defined as an undesirable event that results in damage to humans, assets and/or environment. The risk level in the maritime area is a result of a number of factors relating to the environmental conditions maritime activities are subjected to and the way the work processes are organized (Kristiansen, 2013). Statistical studies of maritime accidents and unfortunate events in ice-covered areas in 1995-2011 showed a general lack of information from the area under the jurisdiction of the Russian Federation (Pastusiak, 2014). So far, there is no detailed database of accidents happened in the Russian part of the Arctic.

In this report we use data provided by the Murmansk Maritime Rescue Coordination Center (Murmansk MRCC) within the last three years. In total, according to the statistical data of EMERCOM, anthropogenic emergency situations show an increase in the Arctic zone, with accidents occurring, in different time periods, in/on:

- transport sector – 25-32%;
- process equipment (fires/explosions) – 18-39%;
- residential and administrative buildings (collapse/fire) – 21-39%;
- plants (toxicant emissions) – 8-12%;
- public utilities and sustenance systems – 7-15%;
- pipelines – 4-8% (Chupriyan, 2013).

FIGURE 4 SAR RESOURCES IN THE ARCTIC ZONE OF THE RUSSIAN FEDERATION

Source: http://www.mintrans.ru

Maritime activities in the Arctic can be divided into Maritime transport, cruise shipping, fishing, continental shelf operations including rig operations, supply services, pipeline laying, underwater activities, science, survey and other activities. These activities are discussed in the following section.

MARITIME TRANSPORT

There was a dramatic decline in harbor activity after the fall of the Soviet Union. Some harbors have lost their position entirely and have very limited traffic today. Then there have been a decade of slight increase in cargo volume, among others related to mining and oil and gas transport. Transit cargo shipping through the North Eastern Passage or the Northern Sea Route (NSR) has increased more than 10 times from 0.11 million tons (4 passages) in 2010 to 1.36 million tons (71 passages) in 2013. However, after four years of increased use of the Northern Sea Route by vessels going in transit between Europe and Asia, a steep downturn happened in 2014. The amount of cargo transported in transit dropped by 77 % compared to 2013. According to the Head of the Northern Sea Route Administration Aleksander Olshevskiy, the negative development had nothing to do with the current political situation. He referred to two possible reasons for the downfall in cargo transport: EvroKhim, who used to transport bulk cargo from Murmansk from the Kovdor Mining Company, was not able to agree on prices with its customers and freighters and had therefor shipped 200,000 tons less than usual. The other reason was that Novatek was no longer shipping out gas condensate from Vitino on the Kola Peninsula but from Ust-Luga outside St. Petersburg (BarentsObserver, 2014).

TABLE 4 CARGO TRANSPORTATION BY THE NORTHERN SEA ROUTE, INCLUDING TRANSIT (THOUSAND TONS)

Year	2013	2014	Beginning of December 2015
Transit	1,176	274	39
Total	3,914	3,982	5,152

Source: Monko, 2015

The advantage of connecting the Atlantic with the Pacific ocean with a 24% distance reduction (for Shanghai–Rotterdam) is offset by many factors including harsher weather and free-floating sea ice, requiring more expensive ship construction, and winterization investments. Remoteness, lack of broadband communications, and limited SAR capabilities increase the risk of Arctic operations. Shallow waters limit vessel size, and ice movements lead to unpredictability of the ships' arrival time (Keil and Raspotnik, 2014). The statistical data NSR in 2015 have proved the tendency of decreasing transit transport within via the Northern Sea Route.

The shipping between Russian ports within the NSR is, however, increasing. Cargo to and from Russian ports along NSR has gone up from 2.8 million tons in 2013 to 3.7 million tons in 2014, and 4.5 million tons in 2015. Most of this increase comes as a result of large oil and gas developments in the Russian Arctic, like the huge Yamal LNG project, and the Prirazlomnaya platform in the Pechora Sea (BarentsObserver, 2015). Throughput of the sea port of Varandey for 10 months in 2015 was 5.5 million tons, indicating a growth of 11.4% (TrLog, 2015).

There are some trends indicating further increase of shipping. The project of the Murmansk transport hub construction was included in the state program "Modernization of transport system of Russia". The project objectives are following: the creation of a transport infrastructure on the Western shore of the Kola Bay including the construction of the railway line Vikhodnoi – Lavna, the creation of coal and oil terminals, the development of the existing infrastructure on the Eastern shore of the Kola Bay (Tukavin, 2015).

Mezhregiontruboprovodstroy JSC at commercial port of Arkhangelsk also installs new areas for the transshipment of multipurpose cargo by sea. New terminal is being built on the east coast of the river of Northern Dvina. This cargo port area is specifically designed to provide oil and gas projects implemented in the Arctic (Kuzmina, 2015).

On the Novaya Zemlya Archipelago the nuclear submarine (NPS) K-27 was scuttled in 1981. The presence of the reactors and radioactive nuclear fuel remnants may lead to the continued heating of the inner cavities of the submarine and as a consequence to constant heat flow from its surface which is an obvious danger including risks associated with plans to refloat and transport the submarine for the further dismantlement (Dmitrievsiy et al., 2015). In November 2015, Russia's national operator for radioactive waste management received approval from the Arkhangelsk Regional Legislative Assembly to allow subsurface storage of low- and medium level nuclear waste beneath the permafrost of the Novaya Zemlya Archipelago in the Russian Arctic. Thereafter, the risks related to the transport of nuclear waste on vessels may occur in the Russian part of Arctic (Bellona, 2015).

From 1900 to 1985, there were reported 7 forced overwinterings, 14 force drifts with ice, 21 shipwrecks, and 3 damages by ice in the Kara Sea. Compared to Arctic Eastern Seas, the Kara Sea had the largest number of accidents, partly due to the relatively high intensity of navigation and not because it sustained the worst ice conditions. After 1990, there were quite a few events in Russian Arctic because ice navigation practically ceased except for the Murmansk-Dudinka route. Information about the current state of affairs in the Russian Arctic in extremely scare (Marchenko, 2011).

According to the Safety and Shipping review 2016, there has been an increase in the maritime accidents in the Arctic area as a result of the increased activity during the recent years (Alianz Global Corp.&Speciality, 2016).

TABLE 5 ACCIDENT STATISTICS IN THE ARCTIC

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Machinery damage/failure	2	3	5	13	14	16	12	13	20	27	125
Wrecked/stranded	1	4	10	11	14	9	9	8	10	14	90
Miscellaneous			5	1	4	4	2	6	5	5	32
Fire/explosions			3	1	2	6	6	1	4	2	25
Collision				1	4	10	4	4	2		25
Contact (eg harbor wall)			1	1	1	3	1	3	6	4	20
Hull damage		1	3	1	6	2	2	1	2	1	19
Foundered			1	1	2		3	1	1	2	11
Total	3	8	28	30	47	50	39	37	50	55	347

Source: Hoevic, 2015

In 2014, there were 55 shipping casualties in the Arctic, compared to only 3 a decade ago. Between 2005 and 2014, there were reported 31 total losses in the Russian Arctic and Bering Sea.

As illustrated in the figure, machinery damage/failure is the principal cause of the casualties; causing 36% on the incidents, 9% of the casualties are due to hull damages and 6% due to contact. The accidents statistics does not state how many of the contact casualties that are caused by contact ice, but implies that several of the casualties are related to contact with the harbor wall (Hoevic, 2015).

According to the statistics of the Murmansk Maritime Rescue Coordination Center, there were 40 accidents in its responsibility area within the period from 2013 until November 2015. 43% of these accidents were caused by machinery damage/failure. As Table 6 demonstrates, the number of incidents has increased in 2015. That can be explained mostly by the increased maritime traffic.

TABLE 6 ACCIDENT STATISTICS IN THE RESPONSIBILITY AREA OF THE MURMANSK MARITIME RESCUE COORDINATION CENTER

	2013	2014	2015
Machinery damage/failure	8	7	7
Wrecked / stranded			1
Fire			2
Medical assistance	4	2	7
A crew member overboard		1	1
In total	12	10	18

FISHING

The total catch of fish and seafood products in 2015 is 262,507 tons, which is an increase of 42,729 tons compared to the last year (56% of the Murmansk region). The fishing fleet consists of more than 2.5 thousand small and larger ships. In 2014, there were 46 emergency cases involving fishery fleet of the Russian federation. In total, the accident rate increased by 8% (MAIB, 2015).

According to the statistics of the Murmansk MRCC, the most emergency calls were received from fishing vessels: 7 out of 10 in 2014 and 16 out of 18 within November 2015. In the most cases, the fishing vessels needed assistance in towing due to machinery damage / failure. In 2015, there were reported two fires onboard of fishing vessels, and one vessel was stranded. Fortunately, these accidents did not cause severe consequences.

Incidents with fishing boats are frequent in the area. They produce the same problems/consequences mentioned above, but on a smaller scale. This type of accident has a relatively high probability of occurring, though. There were not registered large accidents with human losses in the western part of the Arctic but a severe capsizing in the Okhotsk sea in 2015 shows the challenges of SAR operations in Arctic waters.

The tragic event with the refrigerator trawler “Far East” happened in April 2015 in the Sea of Okhotsk shows all the difficulties the emergency services face by maritime accidents in low temperature conditions. The wrecked vessel did not get time to send distress signals. In some minutes all the crew of 132 seamen came to icy water. 26 fishing vessels were close by the emergency site but only 63 seamen were rescued.

Oil and gas activity

Russia is the second largest natural gas producer and the third largest oil producer in the world. The oil and gas receipts constitute approximately 52% of the federal budget and are about 70% of the Russian exports (according to 2012 statistics of PFC Energy) EIA (2015). The oil and gas industry is situated mainly within five oil and gas producing regions: Western Siberia (about 70% of all Russian oil production), Volga-Urals region (25%), Timan-Pechora region (6%), North Caucasian and Far East regions. The production of oil is distributed among the regions as following (at 2012, thsd. BPD): Western Siberia - 6,422; Urals-Volga - 2,312; Krasnoyarsk – 368; Sakhalin – 283; Komi Republic – 259; Arkhangelsk – 249; Irkutsk – 201; Yakutiya – 133; North Caucasus – 64; Kaliningrad – 26.

During the last few years, there has been an increase in offshore exploration activity. Russia possesses vast hydrocarbon resources in the North Shelf and the Arctic shore. In the Arctic Shelf Russia has assessed resources up to 100 bln. tn. of oil equivalent (Giles, 2014).

The Russian petroleum industry moves offshore towards the shelf. Ferries and combined transport-passenger vessels deliver supplies and personnel to the drilling platform Prirazlomnaya and other Arctic sites from the coastal regions. Besides, there has been an increase in offshore oil and gas exploration activity. As an example, an expedition in the Kara Sea included 10-15 vessels with crews of several hundred people. The logistics in this area is complicated, hampered by the lack of harbors and other infrastructure such as harbors and airports. There is also a limited transport infrastructure in many coastal communities of the White Sea and Barents Sea. Ships perform regular passenger transportation and freight, but the hydro-meteorological information is not always sufficient. The navigators are forced to rely on their experience and good skills.

Rosneft and Eni plans to operate on both the Norwegian side of the Norwegian-Russian border in the Barents Sea (Intsok, 2014). Rosneft and Statoil have plans for a joint venture in the Perseyevsky field in the northern part of the Barents Sea. They will perform seismic activities in 2016-2018 and plan drilling in 2020. The timing of the development of exploration, exploitation and transport will very much depend on the international prices of oil and gas and the development in political relations. The fields that have been under construction in Russia will, however, represent a significant increase in shipping activity.

The number of accidents related to oil and gas industry in the Arctic and subarctic areas are quite small. Only the Kolskaya Rig accident (2011) resulted in the loss of human lives as the rig capsized due to stability failure and rough weather. The 'Kolskaya' jack-up rig, operated by Russian offshore exploration company Arktikmorneftegazrazvedka (AMNGR), capsizes while being towed in a storm, some 200 kilometers (125 miles) off the coast of Sakhalin island. The rig had 67 crew aboard of whom 14 were rescued [Reuters, December 18, 2011]. A similar accident happened on November 7th, 2014: the jack-up rig "Saturn" was damaged by the storm while being towed to Murmansk after completing construction works on a well in Pechora sea.. The crew was partially evacuated and towing had been suspended. The press service of the company assures "there were no incidents or disasters at the jack-up rig" (BarentsObserver, March 10, 2014).

The Usinsk accident (1994) was of type pipeline leak and resulted in a large oil spill. The Nefterudovoz-57 ship collision accident (2003) also had environmental related consequences (Basharat, 2012). The accident on the Molikpak rig in the Sakhalin shelf within the Sakhalin-2 project (2009) resulted in 165 l oil product spill on the ice near the rig. The oil spill response was conducted effectively and there weren't any environmental related consequences in this case (Shurikhina, 2013).

Other threats the oil offshore activities cause are environmental conflicts. The so-called Sunrise case happened on the 18th of September 2013, when six Greenpeace activists approached the Prirazlomnaya platform from the Arctic Sunrise, using inflatable boats. Two of them were arrested by the border guards of Russian Federal Security Service's Office in Murmansk Region and delivered on board the Ladoga search and rescue vessel. In 19 September, the helicopter-borne border guards of the Russian Federal Security Service seized "the Arctic Sunrise" in the exclusive economic zone of the RF to convoy it to Murmansk (RIA novosti, 2013).

The most dangerous and discussed events possible in the region are ships accidents resulting oil spills. Fortunately, there have not been any large marine oil spills in the Arctic, so there is not much experience to learn from. It is known that volumes of oil spills by shipping is 23-26 times bigger than by oil production (Bogoyavlinsky, 2014). If oil and gas traffic in the Arctic increases, there is a higher risk for collisions of vessels and the number of vessels running aground. The Marine Rescue Service of Rosmorrechflot provides a full range of services to address oil spills in Russia (http://morspas.com/en/services/osr).

The probability of such events will grow along with increasing activity level and will rise the concern for search and rescue capacities, and for security issues. Considering maritime activity related to the oil and gas activity, the probability of incidents increases during the following technological stages:

- delivery of crews and personnel to the drilling platforms and shipping terminals by air transport;
- connection and disconnection of cargo flexible pipeline during the operation of loading oil into tankers;
- destruction of the integrity of subsea pipeline cargo connecting the coastal tanks with Varandey shipping terminal (Monko, 2015).

CRUISE SHIPPING

Russian companies have long time experience with cruises to the North Pole on "Rosatomflot" icebreakers. Promising cruises to the North Pole include visits to Svalbard and along the NSR, for example, the route "Murmansk - Svalbard - Franz Josef Land - Severnaya Zemlya and Bolshevik Island - Wrangel Island" and other marine tourism and recreation routes. There are plans for the extension of the route of the Norwegian company Hurtigruten cruises to the ports of Murmansk and Archangelsk and to the Solovetsky islands (rus-arc.ru).

The interest for Arctic tourism is growing. Cruise vessels touched at the Arkhangelsk region ports 23 times in 2015. During the recent years, there have been around 10 vessels on routes every summer. According to the governor of the Arkhangelsk region, Igor Orlov, there has been a 70% increase of tourists visited Franz Josef Land and Novya Zemlya in 2015 compared to 2014 (Figure 4). The reason for such an increase of cruises is the opening of the maritime frontier control office in Arkhangelsk (Dvinainform, 2015). Besides, direct cruises Svalbard - Franz Josef Land are launched also in 2015. In addition, there is some traffic involving private yachts and sailboats.

There is a lot of uncertainty about the tourist traffic in the Russian Arctic area. Larger cruise vessels in the remote part of the Northern Sea Route and explorer cruises close to ice and in areas with limited infrastructure may increase the risk. The tourist industry would like to explore areas in the Northern regions and find ways where few have travelled. This may imply more traffic in the most Northern parts of Russia north of the Wrangel and New Sibirian Islands, Severnaya Zemlya and Novaya Zemlya and up Franz Josefs land as close to ice areas as possible.

During recent years, there were not reported severe incidents involving cruise ships. According to the statistics of the Murmansk MRCC, two yachts had machinery failure in 2013 and they were towed to Murmansk.

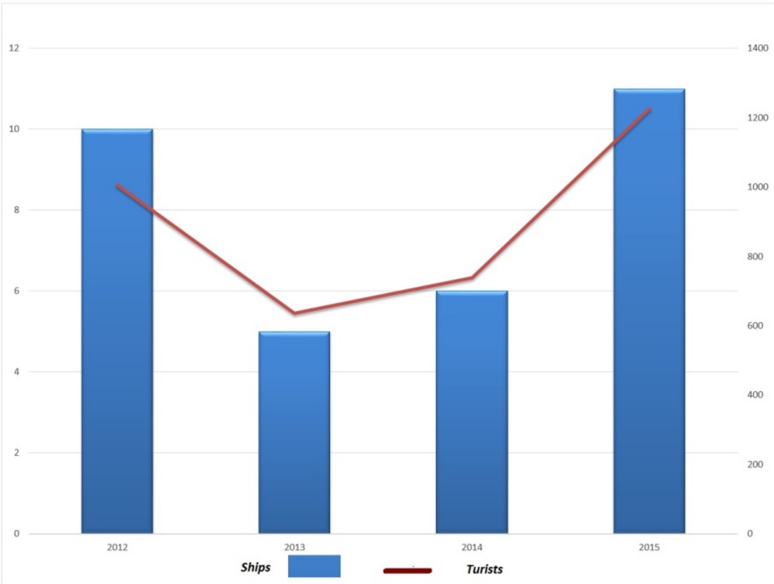


FIGURE 5 THE NUMBER OF VESSELS VISITED ARCHIPELAGO FRANZ JOSEF LAND IN 2014 AND 2015

Source: http://www.rus-arc.ru

Scientific research and other activities

The Northern fleet has its base on surface ship at Severomorsk and for submarines at Vidyayevo, Gadzhiyevo, and Polyarny. It has 8 operational SSBN submarines and 18 general-purpose nuclear-powered submarines. It has fairly modern and well-maintained surface warships, including the aircraft carrier Admiral Kuznetsov, one nuclear cruiser Pyotr Veliky, and six destroyers. Russia has opened new military bases at the New Sibirian Island and Franz Josef land.

Research expeditions also have increased in number in the Western part of the Russian Arctic. In 2015, the annual expedition "Arctic Floating University - 2015", the research project of the Northern Arctic Federal University, passed 3351.5 nautical miles (6208, 988 km) in the White, Barents, Pechora and Kara Seas. Total travel time was 20 days and eight hours. The ship went through three storms that required changing the itinerary of the expedition (UArctic, 2015).

Kara-Winter-2015, scientific-exploratory expedition, organized by the oil company Rosneft with the support of the Arctic Research and Design Center and FSBI Arctic and Antarctic research institute has become the largest Arctic expedition in the world in recent 20 years by the scope and the structure of works. Explorations lasted for ten weeks and involved the Yamal atomic icebreaker, which went from the Barents Sea up to the East Siberian Sea almost through all the shore of the Russian Arctic. The expedition included complex of meteorological, oceanographic, ice patrol, glaciological and biological observations (Rosneft website, 2015).

There haven't been reported any large research expedition accidents within last years. According the statistics of the Murmansk MRCC in 2013, a fishery research vessel was towed to Murmansk due to machinery failure.

Russia is today the most experienced nation with respect to ship operation in ice and low temperatures. In addition to the basic rules there are several guidelines covering practical operations (Barents 2020, 2013). There are already stringent measures in place to insure low probability of accidents: such as vessels and personnel training requirements, compliance with international and national codes, etc.

According to the development strategy of the Arctic zone of the Russian Federation and national security for the period up to 2020, the establishment of integrated security system for the protection of territory, population and critical facilities of the Russian Federation's Arctic zone from natural and man-made emergency situations shall be provided. This includes the development and implementation of projects in the exploration and developments on the Arctic continental shelf and coastal areas, and other infrastructure projects in order to improve the system of state management of social and economic development. The organizational structure of management and shipping safety must be improved; integrated safety shipping system must be created in the Russian part of the Arctic.

To achieve these goals, 10 maritime rescue centers will be located in:

- Dudinka
- Murmansk
- Arkhangelsk
- Naryan-Mar
- Vorkuta
- Nadym
- Tiksi
- Pevek
- Provideniya
- Anadyr

(RiaNovosti, June 1, 2015):

The Russian Air Force in October 2013 re-opened the Temp airfield on the Kotelny Island, which is planned to be the first in a chain of similar bases all along the Northern coast of Russia (BarentsObserver, 2013).

One of the main challenges for a more effective use of the sea route is the need for new icebreakers. The president of the Russian Federation Vladimir Putin said in 2010, Russia planned to build at least three nuclear icebreakers of the new generation in the period from 2012 to 2020. It should be noted the icebreakers and ice class rescue vessels are and will also act as “floating” SAR and oil spill response units. Within the Federal Target Programme “Russian Transport System Development in 2010–2020”, 40 rescue vessels are planned to build. Besides, the RF Marine Activities Strategy until 2030 stipulates the creation of 70 rescue vessels for the Defense Ministry, EMERCOM, and Transport Ministry.

The federal program "Development of civil marine engineering" in 2009 - 2016 provides the development, design and construction of a significant number of civil courts (DGRF№103). Many of them have already been commissioned. These include vessels of the auxiliary fleet, river passenger, crew boat, marine salvage vessels and tugs, icebreakers, including line services and nuclear, as well as many others. From 2000 to 2015 the Russian fleet increased by more than 300 sea and river vessels of auxiliary and technical purposes (Ivanova, 2015b). First of all, the program is being implemented in the interests of the federal system of civil maritime activities. Marine and river transport vessels of small tonnage and non-propelled fleet (barges and barge-towing trains) are not included in the program but this fleet transfers a large part of multipurpose cargoes.

TABLE 7 NEW BUILD SHIPS FOR AUXILIARY AND TECHNICAL PURPOSES

Completed	Under construction
38 rescuer, diving ship and firefighting vessels	8 Icebreakers
15 ships for rescue service	159 tugs 4 ship-fueler
15 ship-fueler	10 pilot boats
3 marine and river icebreakers	3 support vessel for the service of lighthouse and navigation equipment

Source: (K.Ivanova, 2015b)

3 CONSEQUENCES OF DIFFERENT INCIDENTS

This section discusses consequences of five types of maritime accidents:

- Grounding that means that the ship hits land or underwater rock. Areas where most of the groundings take place are port approach areas, straits, channels, roadstead areas (especially in the Arctic).
- Damage due to collision includes both collision with other vessels/sea installations and sea ice.
- Fire breaking out on board.

- Violence - incidents of violent behavior towards persons and physical installations.
- Other types of accidents, for example construction failure.

GROUNDING

The main consequences of grounding in the Arctic are damage to the ship's constructions and cargo, oil spills, crew injuries, and ship owner's financial losses. Higher requirements to vessel's technical quality, increased demands for coastal sailing certificates, pilot services and the vessel traffic control system have reduced the frequency of grounding. Even though grounding of cargo vessels and cruise ship may occur rarely, it may have severe consequences for the environment, not the least because of the heavy fuel oil used and because of vulnerability of coastline as to wildlife, fisheries, fish farming, tourist and leisure activities. The oil spill recovery may also be severely hampered by bad weather, ice and snow.

We can see some of these consequences in the case with the Russian dry cargo vessel Viktor Koryakin.

The Russian dry cargo vessel Viktor Koryakin with crew of 12 and cargo of timber was pushed ashore by gale force winds while anchored by the coast of the Rybachiy Peninsula in the Barents Sea on December 18, 2007. As no helicopters was available at the Russian side, the Joint rescue Coordination Center (JRCC) Northern Norway received a call that a Russian cargo vessel was in trouble outside the Rybachiy Peninsula. They scrambled the nearest Sea King rescue helicopter and after three hours, the Sea King helicopter from Banak (Norway) had rescued all the twelve sailors from the vessel. During the dramatic operation, the vessel broke in two. Fortunately, no large oil spill occurred (BarentsObserver, 2010).

DAMAGE DUE TO COLLISION

In general, collisions are rare in the Arctic, since the traffic density is much lower. However, once they happen they have very serious consequences, depending of type of vessels taking part in the collision and may include crew injuries or even fatalities, oil spills, other types of environmental pollution, damage to the ship's constructions and cargo, and of course ship owner's financial losses.

Due to heavy ice conditions severe damage to the ship may occur as shown in the case with MV Nina Sagadak.

The MV "Nina Sagaydak" sank October 9, 1983 in Long Strait. In early October, the ship was in a caravan under the wiring icebreakers "Leningrad" and "Captain Sorokin". The pressure of the ice increased dramatically due to a strengthening North-westerly wind. The ship was jammed by big, old drift-ice, including the propeller and rudder. With the motion of the ice, the wheel arbitrarily shifted from side to side up to 90 degrees. As a result, the limiters were broken off the rudder stock. The icebreakers that came to help the vessel was not aware of the movements of the ice and the general drift to the Southeast with the pressure of the ice on the ship.

Between the ships in the caravan there formed a cushion of compressed ice. The ship "Kamensk-Uralskiy", lost control in the drift, stern piled into the MV "Nina Sagaydak". The list of "Nina Sagaydak" reached 13 degrees. The position was complicated when the ship "Kamensk-Uralskiy" side piled into the tanker "Urengoy". At one time, three vessels drifted together.

The ice ridge rose above the main deck of the vessel "Nina Sagaydak". On 8 October the crew experienced deformation of the port side of the ship with cracks in the hull. The water began to leak into the engine room. The list reached 30 degrees to starboard. The crew left the ship by helicopter and was delivered to the icebreaker, The deck entered the water, and the ship sank on October 9 (Tsoy, 2009).

In September 2013, the 138 m long tanker Nordvik was struck by an ice floe and suffered water ingress in one of the ballast tanks when sailing in the Kara Sea. The vessel, which was loaded with diesel, an Ice 1 class tanker, was permitted to sail in the Northern Sea Route in light ice condition. The conditions were regarded as medium in the period of the accident. The Federal agency for sea and river transport reported that Nordvik acted irresponsibly when entering the waters with medium ice conditions without having assistance of an icebreaker. On the other hand, experienced captains stated that it was possible to unintentionally end up in an area with medium ice conditions, as the conditions change rapidly. The accident revealed that ship owners do not always comply with the flag state rules, in this case Northern Sea Route Administration, when operating in their jurisdiction.

Fortunately, the accidents occurred without any loss of life or significant oil spill. These accidents demonstrate that even though the vessels are designed to operate in light ice condition, an impact casualty with drifting ice can result in severe damages to the hull. It can be difficult to differentiate a large ice floe from a bergy bit (Basharat, 2012).

FIRE ON BOARD

Fire on board is a very serious threat, especially in the Arctic. The main consequences of fire are injuries and loss of human lives, ship owner's financial losses, damage to the ship's constructions and cargo and environmental pollution.

The nuclear Ice breaker "Vaigach"

At night from 14th to 15th December 2011 there was a fire onboard Russian nuclear icebreaker Vaigach, on route from Dudinka to Murmansk. The fire started from second engineer's cabin. There was a lot of smoke, it quickly spread to all cabins of the ship's superstructure, and there was several explosions on various levels. Thanks to proper professional actions of the captain and the crew, the fire was quickly extinguished.

The passenger vessel "Alushta"

In February 2010, a fire broke out onboard the passenger vessel "Alushta" repaired at the shipyard "Krasnaya Kuznitsa" in Arkhangelsk. The fire started at 10.45 am by a hard frost outside. Onboard the ship there were 30 workers, four of them got burned and toxic poisoning and were taken to hospital. Others were evacuated successfully and were not injured. By 2 pm, the ship was full in fire. Firefighting was complicated because of the vessel construction with many passenger cabins and high combustion temperature. As a result, the ship was completely burned out. The loss of this vessel caused very significant damage to the tourism industry and transport supply in the Arkhangelsk region (Rivportal, 2010).

These examples show how dangerous can be fires on ships. Statistics demonstrate that in the sea the fire rate is lower than during vessels repairmen or construction. However, in the case of fire in the open sea, the consequences can be very dramatic (MAIB, 2015).

VIOLENCE AND TERRORISM ACTIONS

Violence normally includes attacks on vessels, either as piracy or terrorism. Fortunately, there have never been any cases of piracy, terrorism or high-jacking in the Russian Arctic. Nevertheless, the attack by the international activists of Greenpeace on the Prirazlomnaya platform at 04:00 a.m. on the 18th of September 2013 was regarded by the authorities of the Russian Federation as a pirate attack. The authorities explained that this act might cause injuries of people and the construction damage. Russian border guards seized the Greenpeace icebreaker Arctic Sunrise and its multinational crew. However, the actions of Greenpeace were non-violent, therefore, the case was reclassified later as hooliganism (Bellona, 2014). Russia indicated that the matter was an issue of internal Russian law involving criminal acts against Russian property. As mentioned above, six Greenpeace activists approached Prirazlomnaya platform from the Arctic Sunrise, using inflatable boats. Two of them were arrested by the border guards of Russian Federal Security Service’s Office in Murmansk Region and delivered on board the Ladoga search and rescue vessel. 19 September, the helicopter-borne border guards of the Russian Federal Security Service seized the Arctic Sunrise in the exclusive economic zone of the RF to convoy it to Murmansk (RIA novosti, 2013).

The Russian system of counter-terrorism in maritime regions continues to advance, including the Arctic zone. The decree of the President of Russian Federation Vladimir Putin institutes that the Maritime headquarters for counter terrorism will be created in Kaspiisk, Murmansk, Simferopol, and Petropavlovsk-Kamchatsky and Yuzhno-Sakhalinsk, reports TASS. The relevant document published on the official website of legal information.

"To organise in the cities of Kaspiisk, Murmansk, Petropavlovsk-Kamchatsky, Simferopol, Yuzhno-Sakhalinsk operational headquarters in marine areas (basins) for planning for the use of forces and means of Federal enforcement authorities and their territorial bodies on the fight against terrorism, management of counter-terrorism operations in the territorial sea, exclusive economic zone and on the continental shelf of the Russian Federation and in other Maritime space within which the Russian Federation exercises sovereignty, sovereign rights and jurisdiction, as well as on ships, flying the national flag of the Russian Federation", — stated in the decree of the President of the Russian Federation (Presidential decreePutinNo664, 2015).

Russia will establish a new Russian National Guard directly subordinated the president authorized to use force and weapons without warning in cases of threats against civilians or soldiers. It can apply special means like water cannons and armed vehicles to disperse rallies and will have the right to control documents and detain individuals (The Independent Barents Observer, April 12, 2016).

There may happen cases of violent behavior among the seafarers due to physiologically depressing

Arctic climatic condition (Polar nights, lack of sunlight, sensory hunger). The main consequences of violence are injuries and loss of human lives, ship owner's financial losses, damage to the ship's constructions and cargo.

Terrorist attacks on infrastructure and vessels have never happened in the Russian Arctic, but the development of oil and gas activity may increase the risk. This is relevant in the context of open borders in the high latitudes of the Russian Arctic (Franz Josef Land). No matter which of the scenarios will turn out to be true, it is important to maintain preparedness systems at a relevant level.

OTHER TYPES OF ACCIDENTS

Among other types of incidents in the Arctic, the most dangerous are those incurred by ice. Ice can damage ship's hull. Icing can also influence vessel's stability, even leading to capsizing.

The tug boat "Alexey Kulakovsky"

The tug boat "Alexey Kulakovsky" with a crew of 14 people sank at night on August 27, 2010 in the Laptev sea, 20 miles offshore, at a depth of 20 meters. The sea waves in the area was 2.5 meters high, with a western wind of 20 meters per second. The accident killed 11 people, and only three seafarers rescued. The commission of Rostransnadzor during their investigation found that a tow boat "Alexey Kulakovsky" was technically defective and in an unseaworthy condition with shortages in the manning of the crew and failures affecting the seaworthiness of the vessel. The commission found that the owner had made an unauthorized technological cutout in the starboard side. In addition, as reported by the Federal Agency for transport supervision, the tug boat violated the class certificate Russian river register of navigation area for this type of vessel. The cause of sinking of the ship is recognized as the "poor organization on struggle for survivability of a vessel and the incompetence of the captain". Seven people on board the vessel were students in secondary and higher educational institutions. In addition, the captain Soloviev did not have appropriate Maritime permitions (Kulakovsky, 2010).

The drilling rig ”Kolskaya”

A Russian drilling rig named Kolskaya with 67 crew on board capsized and sank off Russia's far eastern island of Sakhalin on the 18th December 2011 while being towed to a new location through a winter storm, within 20 minutes in the Okhotsk Sea. The accident took place at the temperature of -17 degrees below zero with water temperature 1 degree Celsius. The platform capsized before the crew could get to their rescue rafts. (Grove and Akin, 2011).

Ice and water damaged the rig and caused water to enter in the vessel thereby causing the rig to sink. The oil and gas company AMNGR was responsible for the rig and according to Kireeva and Kaminskaya (2011) The rig, built in Finland in 1985, had been working on a minor gas production project in the Sea of Okhotsk for a unit of state-controlled gas export monopoly Gazprom (Grove and Akin, 2011). The most of the victims were drilling specialists and not ordinary workers. The company's higher officials claim that the technical condition of the rig was also adequate. It was said that the staff was forced to take the rig to the desired location even though it was bad weather. The company would have faced a loss if the towing process had to be delayed till February 2012. The accident caused deaths of 16 people and 37 people missing. The rescuers saved the lives of 14 workers on board with the help of planes, helicopters, and rescue vessel while the search for missing people was hampered due to sub-zero temperatures (Basharat, 2012).

The jack-up rig "*Saturn*"

November 7th, 2014 the old jack-up rig "*Saturn*" was under towing from the Dolginskoye field in the Pechora Sea towards Murmansk when it was struck by the storm. The helipad of platform was damaged by the storm and a lifeboat was lost. The entire crew was evacuated from the rig to a following support vessel but returned when *"Saturn"* was moored near Cape Kanin, taking shelter from the storm. The press service of the company assures "there were no incidents or disasters at the jack-up rig" [BarentsObserver, March 10, 2014].

The "*Saturn*", handled by three professional tugboats from Norway, was in a better position than the "*Kolskaya*", which had been towed by icebreakers that were poorly suited for towing (BarentsObserver, November 14, 2014).

The tragic event with **the refrigerator trawler "Far East"** happened in April 2015 in the Sea of Okhotsk shows all the difficulties the emergency services face by maritime accidents in low temperature conditions. The wrecked vessel did not get time to signal distress. In some minutes all the crew of 132 seamen came to icy water. 26 fishing vessels were close by the emergency site but only 63 seamen were rescued. Rescue efforts were disabled by the rough sea; also the search area was very big. The involvement of rescue helicopters was limited by gale-force wind and darkness (rt.com, 2015).

The rescue boat "Barents-1100"

The rescue boat "Barents-1100" was caught in a severe storm on 8 June 2014 in the White Sea. All emergency services were notified. Rescue helicopter "MI-8" and ships were dispatched to help, but it took time for them to reach the vessel in distress. The nuclear submarine "Voronezh" was closer to the place, came first and saved the crew and boat (Marine Telegraph, 2014).

The experience shows that great disasters and unwanted consequences can be avoided if we cooperate during rescue and preparedness improvements. Norway and Russia have a good tradition of mutual help and cooperation. It is very important in border areas.

On April 19 2013, at 14:50, the Lithuanian vessel "Plutonas" reported a crew member of 60 years to have a stroke. The Joint Rescue Coordination Center Northern Norway located in Bodø, asked the Murmansk MRCC for the permission to conduct an evacuation of the ill person from the vessel in the responsibility area of the Murmansk MRCC. The SAR helicopter from Longyearbyen brought the man to Svalbard.

On May 20 2013, the JRCC NN got a distress signal from the vessel "China PSN": that there was an injured person onboard. The vessel was in the responsibility area of the Murmansk MRCC, but the Norwegian Coast Guard Vessel (CGV) "MAGNUS LAGABOTE" could evacuate the injured man quicker to the hospital in Vardø. The permission to cross the Russian border was given orderly; so the Norwegian CGV brought the injured man to Vardø.

April 26, 2015, the vessel "Atriya" reported to the Murmansk MRCC via the phone that the distress signal 'man overboard' was received at 05.40 from the Lithuanian fishing vessel "PLUTONAS". The Murmansk MRCC provided this information to the JRCC, and the JRCC NN in Bodø started to coordinate the rescue operation. The seaman who felt overboard was found within an hour and brought to the vessel. Primarily, his state of health was unknown. The JRCC NN planned to involve a rescue helicopter from Svalbard that could arrive at the emergency site within 2 hours to evacuate the man. Later the seaman was reported as dead (Report of Murmansk MRCC).

The consequences of accidents greatly depend on place and time, crew training, vessel's condition and compliance with the regulations, preparedness to response, rescue and eliminate the negative impact. The most dangerous consequences are coming from large oil spills and accidents with nuclear powered vessels. So far, there have not been any large oil spills or accidents with nuclear icebreakers.

As for violent action and terror, the probability is extremely low. There have never been and highjacking or terror events in the Russian Arctic, they are only a theoretical possibility. However, the consequences both for lives and the environment may be disastrous. As to consequences, one should also take into consideration geographical remoteness of the region, longer response time, and limited search and rescue structure, all that can increase the degree of severity of accident consequences.

The examples above demonstrate that the cooperation between rescue coordination centers, in particular, between the Murmansk MRCC and JRCC NN in Bodø, increase the chances for persons in distress, injured and ill persons to survive. *"The sea is a cruel master and does not excuse mistakes and it means that all emergency services must operate as a single mechanism despite of borders and political situation"* (Report of Murmansk MRCC).

4 RISK ASSESSMENT

The risk assessment for the region is difficult especially as to an evaluation of the probability of an event and the possible consequences of the negative events. These are very difficult estimates, and are often based on statistics, but abrupt, unpredicted situations may occur that has not happened earlier such as the sinking of the cruise ship Costa Concordia outside the coast of Italy due to irrational navigation by the captain. Risk assessment is a crucial task for safe navigation. Risk assessment preferable would be carrying out by for the entire of crew members on a continuous basis.

Considering a risk as the amount of harm that can be expected to occur during a given period of time due to a specific event, one can give indications on the level of risk. The risk is then the product of the probability that an accident happens multiplied by the severity of that harm. In practice, the risk level is usually given a coarse-grained categorization, because neither the probability nor the harm severity can be estimated with accuracy and precision (Borch et al, 2014).

Providing the risk assessment for the Russian Arctic sea regions, we believe that the risk of major accident here is rather low. Some accident types such as violent action and terror have not happened yet, but may also occur in this region. The data for assessments is based on annual reports of Russian shipping companies (JSC "Northern shipping company", "Northern river shipping company ", "Murmansk shipping company", "Ecotec-Bunker", etc.) and observations (Markov, 2015).

The following types of events are taken for consideration (Table 8).

TABLE 8 POSSIBLE VARIATION OF ACCIDENTS, DEPENDING OF SHIP TYPE AND EVENTS

	Tourist/Cruise ship	Cargo/tanker/petroleum Rigs/floaters	Fishing
Grounding	T-G	C-G	F-G
Damage due to collision (sea ice and other)	T-I	C-I	F-I
Fire	T-F	C-F	F-F
Violence/terror	T-V	C-V	F-V
Other reasons	T-O	C-O	F-O

On risk matrixes red area symbols mean high risk, yellow – modern, green – low. We distinguish risk for the environment (Table 9) and for people (passengers and crew) (Table 10) (Marchenko et al., 2015).

TABLE 9 RISK MATRIX OF CONSEQUENCES FOR ENVIRONMENT IN RUSSIAN PART OF BARENTS SEA

5 – Frequently					
4 - Relatively frequently		T-I	F-F		
3 – Occurs		F-G	C-I	T-F, T-G	F-I
2 – Very Rare		C-F, F-O	T-O, T-V	C-O	
1 – Theoretically possible			F-V	C-G,	C-V
	Insignificant	Minor	Moderate	significant	Serious

TABLE 10 RISK MATRIX OF CONSEQUENCES FOR PEOPLE IN RUSSIAN PART OF BARENTS SEA

5 – Frequently					
4 - Relatively frequently		T-I	C-I	F-F	
3 – Occurs		F-G	T-G,	T-F, F-I	
2 – Very Rare		C-F	F-O	C-O, T-V	T-O
1 – Theoretically possible			F-V	C-G	C-V
	Insignificant	minor	Moderate	significant	Serious

The tables above demonstrate that the risk to damage environment is greatest in cases of fire and collision for fishing vessels and fire and grounding for cruise ships. The risks for people is highest in case of fire and other incidents on tourist ships, fire and collision on fishing vessels, and collision of cargo ships. The risk related to both grounding and collision with ice is rather high, but the number of ships is limited. When it comes to fire and terror there are severe challenges in all regions for life, especially for remote areas with severe weather conditions, even though the probability of such events are regarded as theoretically low.

SUMMARY

In this report we have studied the potential risk factors for the marine activities and emergency response operations in the Russian Arctic, consequences of different types of accidents, suggested possible risk matrixes and made some qualitative risk assessments. We came to conclusion that though the level of activity is generally low compared to other regions in Russia, and the risk for major incidents is low, geographical remoteness from search and rescue centers and severe climatic conditions can turn even a minor incident into a major one. We have described human risk factors that prevail as the main reason for accidents, technical risks, weather and institutional factors.

In general, the skill level of the Russian participants in maritime activity complies with international standards. The fleet is being modernized, but there are still some ships more than 10 years old, especially in the fishing fleet. The search and rescue fleet has received major state investments and now has got a number of top-notch rescue vessels of different types.

The examples of incidents in this report (except the case of the MV "Nina Sagaydak") have revealed that the reason for them lies in human factors. In some cases (e.g. the case with a tow boat "Alexey Kulakovsky"), the emergencies are caused by both human mistakes and technical factors. However, in all cases the actions and decisions taken by the crew of the ship, as well as external stakeholders, are crucial. Therefore, special attention should be paid to human resource management, including monitoring of staff health to prevent diseases in sea, safety management during works and navigation operations, to improve the competence of crews and the personal responsibility of every seafarers. Another important issue that is confirmed by the examples is the importance of cross-border cooperation between rescue coordination centers and smooth institutional interaction.

To prepare for future challenges related to possible grow of maritime activity in the Arctic, there is a need to further develop technologies, routines and rescue protocols to reduce the probability of accidents, to improve personnel training as a first measure for risk management, and to achieve strict compliance with existing national and international safety regulations (e.g. the Polar Code). New rescue centers and ports being built along the Russian coast once completed will contribute to illuminating the risk. There is a continues need to test and develop emergency response in teams for different types of incidents including oil spills, collisions, groundings, fires, and even, though rather unlikely, violence such as terrorism.

It is also important to use the experience of international cooperation in rescue and improving preparedness, to avoid disaster and mitigate unwanted consequences. Norway and Russia have a good history and experience of cooperation, and it would be beneficial to develop it further.

PART II Maritime Activity Risk Patterns and Types of Unwanted Incidents. The Norwegian Waters and Svalbard Sea Areas *by Odd Jarl Borch, Natalia Andreassen and Nataly Marchenko*

The increased maritime activity level in sea regions along the coast of mainland Norway and around Svalbard affects all areas of emergency preparedness. The commercial activity in the High North includes coastal transportation, international Arctic routes transits, exploration, development and production of hydrocarbons and other mineral resources, the fisheries, cruise tourism, and other research and government activity. The greater variation in types of activities, the increasing number and types of vessels, pipelines and installations in sea increase the possibility of unwanted incidents. Moreover, the vulnerable environment in the High North contributes to the significance of consequences of the unwanted incidents for human life and for natural environment. We illuminate that sea areas around mainland Norway and around Svalbard have different geographical features.

Mainland Norway and Svalbard are distinguished in the natural and social senses, have different levels and types of maritime activity and should be considered as providing quite different challenges for the emergency preparedness system (Table 11).

TABLE 11 MAIN FEATURES OF THE NORWEGIAN WATERS AND SVALBARD SEA AREAS

Region	1) Svalbard area	2) Mainland Norway (up to Bear Island on the north)
Boundary W-E	00°00’ and 35 °00’ East	00°00’ and 35 °00’ East
Boundary N-S	74 °00’- 90 °00’	66 °34’ and 74 °00’
Natural features	Long polar day and night. Harsh weather condition: low temperature, wind. Sea ice in the North	Short period with polar night/day. Strong influence of North-Atlantic current Polar low No sea ice

Economic features	Population ca. 2800 Very small economic activity	Population: ca 500 000 Rather equal activities along the region. Oil and gas exploration
Political features	Norwegian jurisdiction Unmilitary zone Fishing and coal mining activities of Russia and other nations.	Norwegian jurisdiction
Characteristics navigational difficulties	Sea ice in the North Reduced satellite coverage. Lack of maps.	Storms, Icing, “Heavy traffic” on most common ship routes and ports
Maritime activity	Fisheries, Tourism, Cargo, Science, Tankers (very few)	Cargo, Tankers, Fishery, Tourism, Science
Shipping seasonal variation	Large seasonal variation with peak in summer	Quite stable during the year
SAR features	Local Rescue Coordination Center, Svalbard Governor (2 helicopters, polarsyssel vessel) with help of Longyearbyen Red Cross (emergency equipment), Coast Guard (1 vessel) and Fire services. Banak helicopters may assist. Extremely low human resources.	Joint Rescue Coordination Center Northern Norway in Bodø, 20 Local rescue coordination Centers at police districts. Well equipped with both physical and human resources. Helicopters: 2 in Bodø, 2 in Banak, 3 in Hammerfest, 5 in Bardufoss and ambulance helicopters in Brønnøysund and in Tromsø; surveillance and ambulance aircrafts; and Coast Guard fleet, a great number of voluntary and private organizations.

In order to ensure adequate capacities for an emergency preparedness system, there is a need to increase understanding of the probable risk factors and risk mitigating tools. This chapter provides an overview of dominating stressors and risk factors that are especially relevant for the region of Mainland Norway and Svalbard. Then the expected activity level is analyzed in light of the probability of unwanted incidents. Next, the consequences of possible maritime incidents are presented. The report offers then risk assessment matrixes analyzing the frequency of different types of unwanted incidents and significance of consequences. Finally, it summarizes the study findings and discusses implications for the national preparedness system relevant in the High North region.

1 DOMINATING RISK FACTORS

The industrial exploitation of the High North region is developing faster than the development of necessary infrastructure and consequently the effective emergency preparedness system. The challenges in general are connected to the increased commercial activity, lack of port infrastructure and lack of experience under the harsh natural conditions. This section overviews the important risk factors or stressors that have a great impact on emergency preparedness system in sea areas around Svalbard and along the Norwegian coast in the High North.

1.1 Mainland Norway

The significant undeveloped resources of the Arctic strongly contribute to the increasing interest and significant industrial activities in the Arctic (DNV GL, 2012). Along the coast of mainland Norway there is an increased traffic connected to petroleum, minerals, fisheries, intra- and inter-regional transportation and research activities. The increased traffic density and other activity in sea areas can be referred as operational factors raising the likelihood of accidents. Paaske et al. (2014) highlight global warming which increases the average temperature in the Arctic twice as fast as elsewhere in the world. The increased physical accessibility of the Arctic waters for ships operating may increase the number of unwanted incidents.

The vulnerability of the Arctic environment refers to another stress factor. Environmental factors of the Arctic area contribute both on the likelihood of accidents and the consequences to the environment and human lives. The increased ship traffic can be in conflict with weather conditions and may cause collisions, a variety of hazards, damage for people and for nature. DNV GL (Paaske et al., 2014) in their overview of the risks highlight the negative environmental conditions as dominating in the Arctic region. Risk generating weather factors influence visibility due to snow, fog, storms etc., seasonal variations in light, wind, water and air temperature, current and waves, marine and atmospheric icing. The Norwegian Coastal Administration informs also that extreme weather periods in the region with strong wind and heavy rain happen more frequently and may lead to significant material injuries and fatalities (Kystverket, 2015).

There are some stressors that can be regarded as geopolitical factors. They refer to growing global demand, shifting market conditions, environmental and political conflicts, and changing geopolitics (Stepien et al., 2014). Such factors may influence the situation along the coast even in the relatively stable region of Norway, change the demand for Arctic resources and thus industrial activity.

Paaske et al. (2014) call the lack in experience, navigational competence and crew fatigue as human-related risk-shaping factors. Communication challenges might also have impact on probability of accidents. DNV & FNI (2012) perceive indigenous interests as a risk for industrial accidents in the Arctic with greater consequences for human due to the operators' lack of knowledge.

Coastal Norway is facing some of the same challenges as the Svalbard region especially during winter months: stormy weather, polar lows, darkness, icing and snow. These conditions may severely challenge the safety of the traffic along the coast, and hamper the operations of the preparedness system. Although, the Svalbard region has some peculiar stressors.

1.2 Svalbard area

High Arctic conditions that may affect the probability of incidents include poorly charted waters and remoteness, ice, cold and unpredictable weather, and darkness in winter. In addition, underdeveloped infrastructure in the High North for maritime shipping creates extra challenges, for example limited and unstable radio/satellite communication. This may increase the risk of accidents, and may also represent a barrier for the preparedness system that is to mitigate the consequences of an incident.

Seasonal changes in the High Arctic are more dramatic than anywhere else in the world: freezing and melting sea ice, and going from winter darkness to the midnight sun in a very short time. These influence the likelihood and costs of commercial activity as well as the consequences of accidents.

Climate changes are more visible in the Arctic. The average temperature here is increasing twice as fast as elsewhere in the world, and the polar ice cap is retracting. At the same time, there are local variations in ice conditions from year to year, making predictions difficult.

The important stressors for the preparedness system are people's injuries and missing people due to sinking ships. The possibility of fire and wrecking is just the same as in other sea areas. However, the limited capacities for mitigating consequences of accidents mean that the consequences may be more severe. Better access to information has increased the public's interest in industrial activity. Even though industries such as fishing, hunting, and mining have been there for centuries, the Arctic is perceived as the last untouched wilderness on earth. During recent years, Svalbard has been well known to the public as a popular tourist attraction. In case of possible industrial development, the business actors and authorities are likely to face more public scrutiny than those in the past and in other places.

2 ACTIVITY AND PROBABILITY OF INCIDENTS

The activity of vessels and installations and density of traffic influence directly on the probability of incidents. Therefore, in order to describe probability, the report presents statistics for traffic density, accidents and the types of vessels or other activity in the sea areas in the coastal Norway and around Svalbard.

Ship traffic is one of the most intensive in the whole High North region. The density of the ship traffic pattern for 2015 for the territory of coastal Norway and Svalbard area is demonstrated on the Figure below.

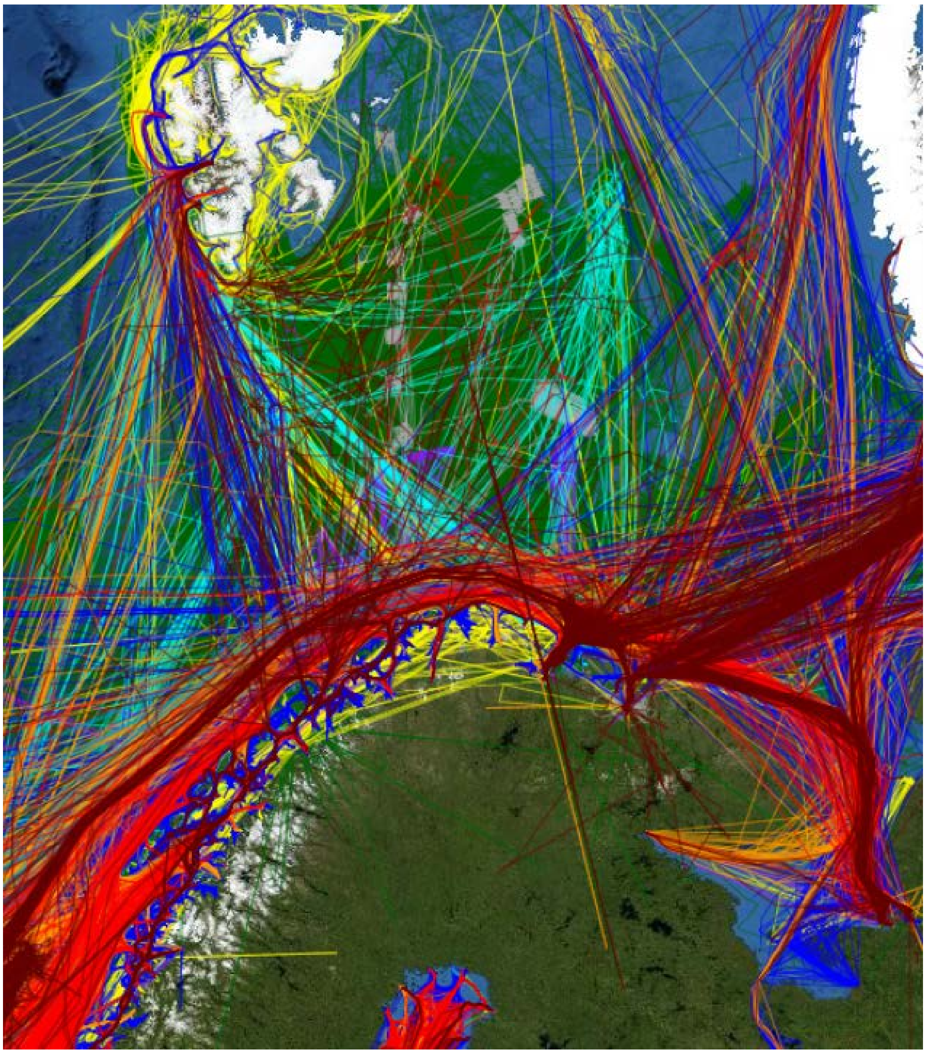
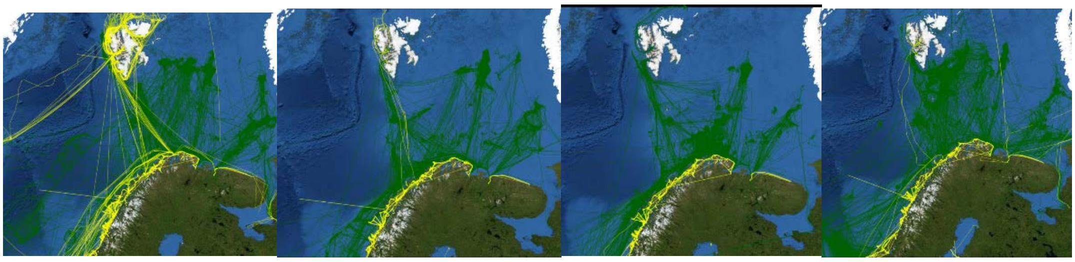


FIGURE 6 SHIP TRAFFIC COASTAL AREAS OF MAINLAND NORTHERN NORWAY AND AROUND SVALBARD, IN 2015

Source: Havbase, Map over Norwegian areas and ship traffic, AIS database of the Norwegian Coastal Administration, http://havbase.no/

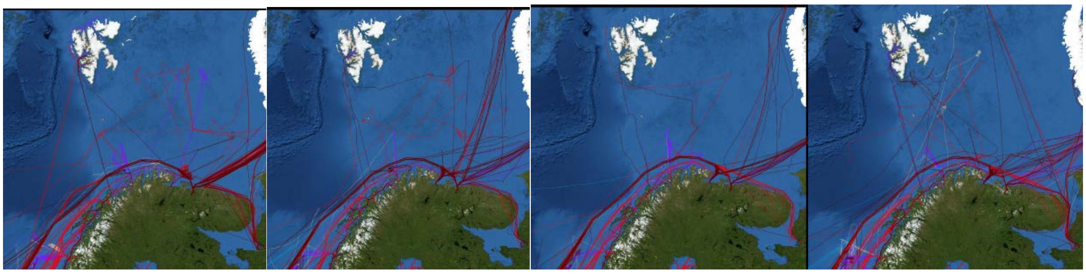
The NCA's Havbase is the most updated online service which provides AIS data. ArcGIS combines and integrates existing data about the environment and human activity in the Arctic. Using the interactive mapping platforms, the following picture demonstrates traffic density of various types of vessels during spring, summer, autumn and winter months.

July 2016 April 2016 January 2016 October 2015



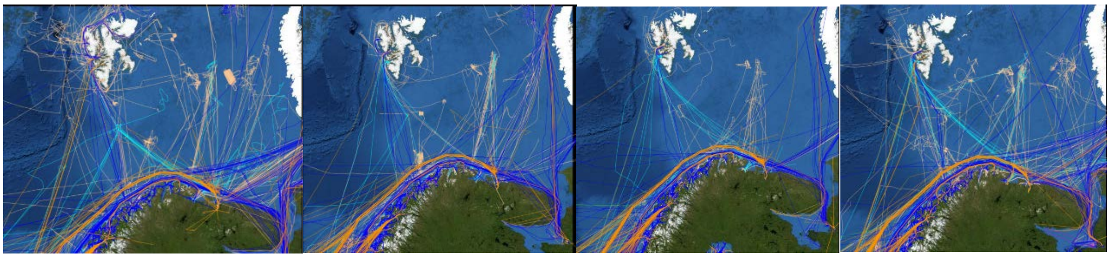
Passenger (yellow), fishing vessels (green)

July 2016 April 2016 January 2016 October 2015



Oil, gas and chemical products tankers (red), offshore supply ships (purple)

July 2016 April 2016 January 2016 October 2015



Bulk ships (orange), general cargo and container ships (blue), refrigerators (light blue)

FIGURE 7 SHIP TRAFFIC LINES FOR DIFFERENT SEASONS AND TYPES OF VESSELS

The Norwegian Maritime Authority controls accidents statistics for all areas in Norway. Table 10 demonstrates 558 accidents on sea registered in their database for the region between mainland Northern Norway and Svalbard for the period from January 2001 to April 2013.

TABLE 12 PERCENTAGE OF TRAFFIC AND INCIDENTS

	Svalbard area	Coastal Norway	Other areas in Northern Norway
Traffic percent	2.71 %	85.32 %	11.97 %
Total accidents	7	529	22
Incidents percentage	1.26 %	94.80 %	3.94 %

Source: ***Fjørtoft et al., 2015***

Most of the incidents happen in the areas between mainland Northern Norway and Svalbard, even though total numbers in the Table 10 show that mostly incidents happen in coastal sea areas of Northern Norway (www.sjofartsdir.no). The register of the Norwegian Maritime Authority includes different types of reported accidents: occupational accidents; grounding; contact damage, piers, etc.; fire/explosion; collision; environmental damage; leaking; capsizing; missing vessels and weather damage. About half of the reported accidents are occupational accidents.

The Joint Rescue Coordination Center (JRCC) Northern Norway has also a register of all incidents that are reported in the sea areas of the Northern Norway (including Svalbard). The amount of registered incidents on sea in the Northern Norway is 1208 in 2015 compared to 1122 in 2014 and 1074 in 2013 (JRCC, 2016).

The Norwegian Coastal Administration reports on all incidents alerts and emission volume in Norway. The overview of all reported incidents divided by different types of events is presented in the Table 13. In 2015 The Norwegian Coastal Administration received 1098 alerts of risk of acute pollution, 545 of them did not cause acute pollution.

TABLE 13 ALL REPORTED INCIDENTS DURING 2012-2015 DIVIDED INTO VARIOUS TYPES OF UNWANTED EVENTS

Reported events	2012	2013	2014	2015
Grounding	87	76	75	73
Vessels in operation	115	160	104	102
Vessels on fire	17	26	18	16
Vessel collisions	17	22	13	11
Other events with vessels	89	138	97	117
Wreck handling (ship)	17	23	23	7
Possible pollution at sea	201	229	152	92
Possible pollution in waterways	-	-	-	6
Offshore	132	172	165	180
Marine mammals	6	4	5	5
Drifting objects	91	98	117	154
Navigation units	19	23	11	4
Land transport	109	138	97	123
Industrial	70	74	65	72
Agriculture	8	12	13	13

Other land-based events	120	108	103	114
International notification and assistance	11	7	6	2
Nature events	-	-	-	7
Total	**1109**	**1310**	**1064**	**1100**

Source: Kystverket, 2015a

Overall, the amount for reported incidents has reduced in 2014 and 2015 comparing to previous years. The possible reason for that is the change in the alerting procedures for incidents near and on land. The volume of unwanted incidents varies between different sea areas and depends on the commercial activity in the areas.

2.1 Mainland Norway

The region has intensive traffic density with a variety of vessels. The coastal sea traffic includes passenger and cargo transport and highly interlinked with different commercial activity in the region. Traffic includes vessels of 55 different nations, where 39% are Norwegian and 15% are Russian. Maritime transport is still dominated by internal and destination traffic. The volume of internal transport in coastal regions is relatively stable. Along the coast of mainland Norway, and from neighbouring countries, smaller and medium-sized vessels are mostly in use. The most traffic includes fishing vessels, cargo ships and tankers (havbase.no).

Traffic statistics for routes with compulsory pilotage between Norway and abroad and between Norwegian ports presented by the Norwegian Coastal Administration, counts for 16942 routes in the Northern Norway for 2013. In addition to those routes, there are many smaller routes that are not obliged for compulsory pilotage (9688 routes in 2013) and vessels exempted from the obligation (293 routes in 2013) (www.kystverket.no). Intercontinental transport is primarily related to the Northern Sea Route (Northeast Passage) between Europe and Asia. There are a few tanker vessels transits under the Norwegian flag each year (http://www.arctic-lio.com/nsr_transits).

Maritime tourism is linked to small and large passenger vessels. There is a strong increase in both the number of ships and passengers and the sailed distance along the coast of Norway. Larger cruise ships with thousands persons on-board are operating. The largest passenger transport ship is the coastal steamer Hurtigruten AS with up to 1,100 people on board. There is also a growing amount of leisure vessels. Among these are many unexperienced sailors and they more often face challenges with the need for help from the preparedness system.

A significant increase in traffic is reached by shipping goods between supply bases and installations on land and floating offshore platforms. Initially the traffic goes from Sandnessjøen and Hammerfest, firstly from the Goliat field, from the Aasta Hansteen gas field in the Norwegian sea and in future from the Johan Castberg field in the Barents Sea. Many involved cargo routes belong to the special category of risk vessels. The Norwegian Coastal Administrations data system reports about 158 risk vessels per month on average for the region, according data for 2015 (Kystverket, 2015b). In 2015, 1899 voyages of "risk vessels" was registered in in the Barents sea area, while in 2014 there were 1642 against 1584 voyages in 2013 (Kystverket, 2015b). There are also many specialized vessels that are designed for the exploration and extraction of natural gas and oil (Arctic Council, 2009). In 2015, 424 voyages transporting oil and gas products were registered in 2015 within Barents Sea (Kystverket, 2015b).

An increased oil and gas exploration activity is expected after the 23 license round in the Northern and Eastern part of the Barents Sea. DNV GL has carried out a risk assessment for two main areas in the licencing round on behalf of the BASEC consortium of oil companies involved in the Norwegian part of the Barents Sea[1]. Their study emphasized challenges such as distances to hospitals, rescue resources and depots, wave heights, wind speed, low water temperatures, fog and icing hampering both helicopters and vessels as risk aspects.

The activity of the fishing fleet takes place both close to shore and in open waters almost all year long. Farther from the mainland Norway there is all-year activity maintained by a number of large sea-going vessels, including factory vessels with a large crew. According to the database from the Ministry of Trade and Fishery, there are 3478 fishing vessels registered in the Northern Norway areas during 2015 (www.fiskeridir.no). In respect of possible incidents, it is important to categorize fishing boats

[1] DNV-GL 2016. AREA Report - SSEPA Barents Sea. South West. Barents Sea Exploration Collaboration

by criteria: engine power or length. The fishing fleet of the Northern Norway includes 1772 small fishing boats with length under 10 meters, 1629 medium-sized and 77 large vessels with length over 28 meters (Fiskedirektoratet, 2016). The overall engine power has a small increase yearly (www.fiskeridir.no).

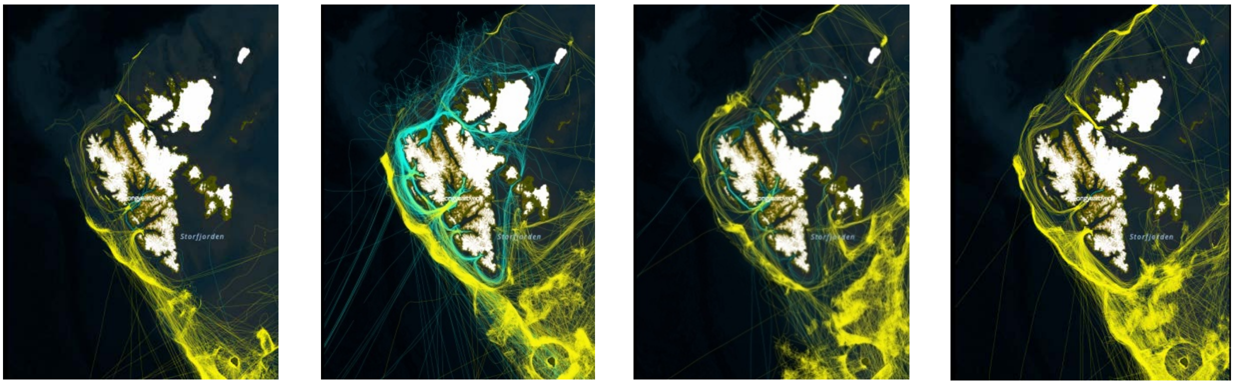
There is also a growing research, exploration and observation activity in the High North, which includes various research vessels designed for multiple purposes including navigation through ice waters. Government vessels can belong to different jurisdictions. The Norwegian coast guard has four larger vessels for operations in the High North including the icebreaker KV Svalbard. In addition, they have 10 vessels for closer to coast operations. The sailing patterns include patrol in the Barents Sea and Svalbard region, and all along the Norwegian coast. In the Barents Sea one-two vessels may be present most of the time. The Norwegian navy has five ultra-modern frigates and six MTB, six submarines and six mine hunters, together with logistics vessel. Not more than 20 per cent of the sailing time of this fleet in 2014 could be referred to the Northern Norway.

2.2 Svalbard area

There are four main groups of vessels in the Svalbard area: tourist, cargo, research and fishing vessels. Vardø sjøtrafikksentral (Vardø Vessel Traffic Services, VTS) is the information unit of the Norwegian Coastal Administration (NCA), collecting data about traffic in the Svalbard zone throughout the year, using the AIS system. The special online service ArkGIS (Arctic Geographical Information System - http://arkgis.org/) has been used to demonstrate images of ship traffic in Svalbard area.

Spring Summer Autumn Winter

Passenger-blue lines; Fishing vessels – yellow lines



General cargo – light blue lines, bulk ships – orange lines

Tankers (chemical product and oil) – red lines, reefers – green lines.

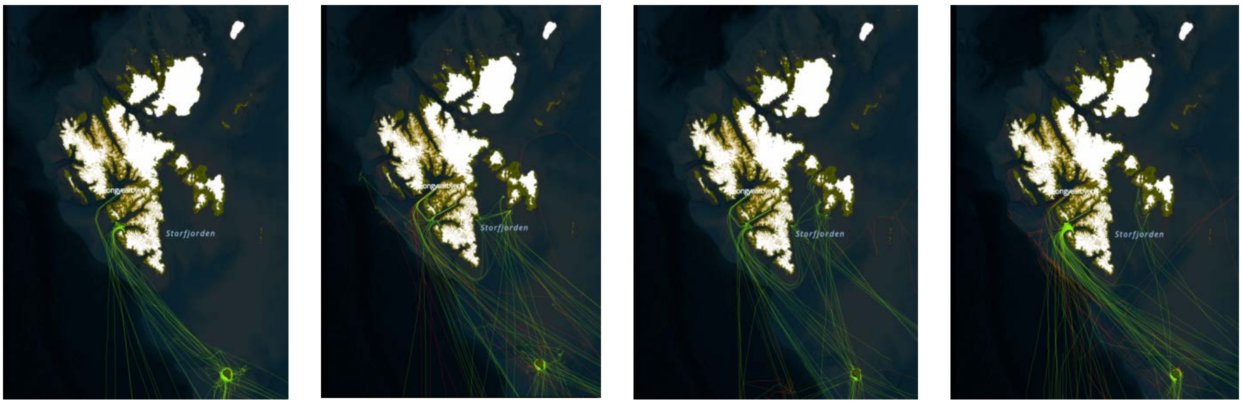


FIGURE 8 SHIP TRAFFIC LINES FOR DIFFERENT SEASONS AND TYPES OF VESSELS

Naturally, the cruise ships dominate by the number of people, but the fishing vessels largely dominate by numbers. Due to ice and weather conditions, the ship traffic has large seasonal variation. The Norwegian Coastal Administrations data system shows that the number of fishing vessels changes from 10-20 in January-May, to 30-40 vessels in June-August, and 50-60 vessels in September-December.

The tourist season starts in May with about 2 ships. In July-August there are 15 to 30 ships, in September around 10, and 2-4 ships at the end of the season until October.

There are 2 cargo ships on fixed routes and 5-6 other dry bulk vessels that have random calls, with about 15-20 trips a year combined. There is also a reefer (freezer) ship, receiving fish from 2-4 Russian trawlers almost all year.

A few research vessels operate year round on Svalbard. Additional 5-8 vessels come during the period July to September. There are about 25-35 calls by ships carrying coal from Svea from July to December, but from 22.september 2016, the transport of coal is reduced because of stop in the production in Svea. During autumn months Barentsburg and Longyearbyen are visited by 2 to 3 bulk carriers. There are also tankers supplying fishing vessels, cruise ships and the villages. The number is about 10 tanker vessel visits throughout the year.

The studies by Norwegian Coastal Administration (Kystverket, 2014) and DNV GL (Paaske et al., 2014), show that there have been 48 ship accidents during the past 15 years in Svalbard. Most of them did not result in significant release of pollutants or damage. A ship accident involving the release of fuel or cargo is likely to occur in Svalbard every sixth year on average, according to analyses future traffic patterns. The average spill size (for the whole area of research) is estimated to 3 ton per/year (Kystverket, 2014). Fishing vessels are likely to be responsible for most such incidents since they account for two-thirds of marine traffic, but accidents involving large cruise ships are likely to have the greatest impact due to their size and amount of passengers.

The Norwegian Coastal Administration expresses uncertainty how the prohibition that restricts vessels to use heavy fuel oil in the national parks (around Svalbard) will affect the maritime traffic that use or bring heavy fuel oil. Currently ships sailing in and out of Isfjorden do use heavy fuel oil (Kystverket, 2014). More detail information about ship traffic and estimated activity in mainland Norway and around Svalbard area is presented in the MARPART project report 1.

3 CONSEQUENCES OF DIFFERENT INCIDENTS

Accidents are the consequences of complex coincidences and factors. The severity of maritime accidents greatly depends on the geographical place and time, the capacity and preparedness to response, rescue and eliminate the negative impact (Marchenko et al., 2015). Historically records of ship causalities identify major losses connected to fire, explosion, grounding, collision and foundering (Soares and Teixeira, 2001). In the Arctic region, these records are tested by quite a few disasters. The range of possible negative accidents include grounding, damage due to collision with sea ice or other objects, fire, terror/ violence, and other reasons (Marchenko et al., 2015).

The Norwegian Coastal Administration reports on the total amount of emissions in sea areas. The statistics for emissions in the Barents sea and Norwegian sea waters is presented in the Tables below.

TABLE 14 NUMBER OF REPORTED EMISSIONS TO SEA AREAS IN BARENTS SEA AND NORWEGIAN SEA

Sea areas	Total emissions 2013	Total emissions 2014	Total emissions 2015
Barents sea	42	38	35
Norwegian sea	70	52	64

TABLE 15 VOLUME OF EMISSIONS TO SEA AREAS IN BARENTS SEA AND NORWEGIAN SEA (LITERS)

Sea areas	Volume emissions 2013	Volume emissions 2014	Volume emissions 2015
Barents sea	6,8	104,6	51,7
Norwegian sea	39,6	283,2	217,8

3.1 Mainland Norway

The high density of maritime traffic in the coastal Norway influences the high probability of accidents; even though the coastal authorities have made important efforts to reduce the probability of severe accidents by means of vessel traffic zones, emergency towing boats, traffic control and certification demands. The cold climate in winter increases the risk to people’s life in accidents because of operational difficulties of rescue operations and the reduced time available for the rescue. Vessels operating all year round have the highest risk. These are fishing vessels and large passenger ships which operate most part of the year.

One of the most serious negative effects on the local ecosystems may be caused by heavy oil spills. As an example, the cruise liner M/V Marco Polo grounded on the Lofoten archipelago in November 2014 with 800m^3 fuel oil on board. The ship was aground on soft mud and refloated the same night without damage to the ship or its 750 passengers. Luckily, no pollution occurred. Otherwise, severe consequences for ecosystems in this area could happen affecting a very sensitive nature, a large amount of tourist attractions and industry.

Following one of the biggest incident in offshore oil and gas activity, the Macondo oil spill in April 2010, the Norwegian Ministry of Petroleum and Energy announced that the incident could become a lesson for safety and emergency preparedness in connection with drilling and well operations on the Norwegian Continental Shelf (PSA, 2014). Subjects that call for special attention in the whole industry in Norway are well integrity, prevention of oil spills, gas leaks and maritime incidents, and modernization of installations and plants. Within the framework for prevention of oil pollution from Arctic maritime activity, Arctic Council plans to strengthen traffic monitoring and management, improve maritime services, reduce risks associated with use and transport of heavy fuel oil (Arctic Council, 2015)

Oil and gas industry represents high risk even though the number of unwanted accidents is very few. Worst-case scenario is a risk approach to assess the probability of a major oil spill together with associated environmental impacts in a particular context. Some assessments were done related to petroleum exploitation in the Lofoten area (Hauge et al., 2014). Norwegian Directorate for Civil Protection DSB (2013) suggested a worse-case scenario of a serious blow-out lasting 43 days with total discharge volume 300000 tonnes of oil on a drilling rig on the Norwegian continental shelf. They assessed that the highest consequences will affect nature and the environment affecting up to 3000 km of coastline and may cost for the economy up to 10 billion NOK. The Risikogruppen (2010) suggested the worst-case scenario for Barents Sea and the Lofoten area. In this especially valuable and vulnerable northern area such a serious blowout as the one happened in the Gulf of Mexico, may have more complications and negative impacts. The Macondo blowout lasted 87 days approximately

41 nautical miles from land and the spill amounted to 800000 cm^3. The worst-case scenario assesses the risk of such unwanted accident can be once in 750 years during the exploration phase. The consequences will have negative effects on the fish species with a recovery period of three years, one year for the beaches, 10 years for the sea birds (Risikogruppen, 2010).

The increased petroleum and oil and gas transport shipping activity in the Barents Sea causes the concern for safety and preparedness (PSA, 2014). Norwegian Directorate for Civil Protection (DSB, 2013) in the analysis of a National risk scenarios highlights a link between the distance sailed (extent of maritime traffic) and the number of accidents at sea that could entail danger to life, health, the environment and material assets. Statistically, there has been a strong increase in the number of navigational accidents since 2005. The increase by 16% is estimated in overall maritime traffic along the Norwegian Coast from 2008 to 2025.

Transport by sea is considered to be a relatively safe form of transport, but the consequences can be serious. Accidents happening closer to the shore can be challenging for coastal transport. Intensive shipping and increased industrial activity mean disposal of all kinds of waste. The approximate amount of oil sludge generated annually by ships operating in the Norwegian and Barents seas is 13,000 metric tons (Arctic Council, 2009). Vessels carry hazardous and/or toxic cargo and may contain radioactive materials. There is a major risk in sea transport linked to uncontrolled emissions of toxic, environmentally harmful materials that can have affect on seabirds, marine mammals and shoreline habitat (DSB, 2013).

3.2 Svalbard area

Oil spills and life-threatening accidents with large cruise ships are the most discussed events due to the consequences and the limited preparedness capacity for search and rescue, hospital care and oil spill response. Fortunately, there have not been any large marine oil spills in the Svalbard area and totally in the Arctic, so there is not local experience to learn from. The most relevant previous oil spill to learn from is the Exxon Valdez disaster (Alaska, March 1989). 42,000 m3 of crude oil were spilled from the reef tanker), which happened in the sub-Arctic and had a range of negative effects on the local ecosystems. International Maritime Organization introduced comprehensive marine pollution prevention rules (MARPOL) through various conventions as a reaction on this event.

There are only few tankers operating of much smaller size in Svalbard area now, so these types of accident and consequences has a very low probability.

It can increase significantly, however, in the case of sea ice reduction and more active usage of Arctic routes for transportation (Smith and Stephenson, 2013).

That is why Norwegian government pays attention to the increasing of preparedness to oil spill (Sysselmannen på Svalbard, 2010). The Norwegian Coastal Administration analyses preparedness against acute pollution mainly based on environmental risk in conjunction with possible oil spills from marine traffic. The report recommends to provide Fast system for deploying booms around leaking vessels during high season, May – November, and provide Contractual coastal OR vessels with a demand for certification and training programs. The Norwegian Coastal Administration suggests further that within the research area there should be a broad selection of vessels and resources. This will enhance the ability to handle operational challenges that are common in arctic conditions. Finally, the NCA will need to cooperate with the Governor of Svalbard to clarify expectations and operational patterns in cases where oil spills may occur (Kystverket, 2014).

The most significant challenge posed by an arctic oil spill is dealing with oil in ice. Ice can make it more difficult to find a spill, reach it and deploy equipment and personnel to respond. However, ice can act as a natural barrier and prevent oil from spreading. Cooler temperatures and waves dampened by the ice can also slow the breakdown or “weathering” process of oil. This can increase the window of opportunity for recovery, dispersants and in-situ burning.

There have been two large accidents with tourist ships in the Svalbard area (Maxim Gorkiy, 1989 and Heanseatic, 1997 – see (Marchenko, 2015) for detail. Thanks to good weather conditions, they both ended without any big injuries or human losses or oil spills. While Hanseatic had Polarsyssel present at the site when the accident happened, pluss 3 coast guard ships during the next 24 hours, the case of the Maxim Gorkiy accident really demonstrated the difficulties of rescue operation in such a remote area.

Possible accidents with fishing boats are frequent in the Svalbard area. They produce the same problems/consequences of two mentioned above, but on a smaller scale. Fishing boats carry a much smaller amount of fuel and usually have 10-30 persons on the board. This type of accident has a relatively high probability of occurring, though.

4 RISK ASSESSMENT

Risk refers to the probability of being affected by the unwanted consequences of a hazard. It combines the significance of consequences and degree of vulnerability. The risk assessments characterize the risks posed to individuals and environment by potentially harmful maritime accidents. Risk estimation is based on an evaluation of the probability of an event and the possible consequences of the negative events. These are very difficult estimates, and are often based on statistics. In this report risk assessments are based on previous studies and statistics and represents a qualitative assessment of the amount of harm that can be expected to occur during a given time period due to a specific event. The level of the risk is then the product of the probability that an accident happens multiplied by the severity of its consequences. In practice, the risk level is usually given a coarse-grained categorization, because neither the probability nor the harm severity can be estimated with accuracy and precision. Some accident types such as violent action and terror have not yet happened, but may occur also in this region. Although this approach has been criticized (Cox Jr, 2008), it is widely used for risk assessment and gives adequate depiction and fruitful ideas for preparedness improvement.

The following analyses in different sea areas used information presented in risk assessments by Norwegian Coastal Administration (Kystverket, 2014, 2015a), DNV GL (Paaske et al., 2014); the SADA report; (Stepien et al., 2014); the AMSA report (Arctic Council, 2009); some provisions from the National Risk Analysis by DSB (Norwegian Directorate for civil Protection (DSB), 2013) and the incidents statistics 2013 of Norwegian Maritime Authority (www.sjofartsdir.no). For the Svalbard area, an overview of Longyearbyen port current and planned activities (Multiconsult, 2014) and risk analysis performed by Governor of Svalbard on 2013 (Sysselmannen på Svalbard, 2013) were used. In addition, risk assessments have been discussed at the MARPART project meeting in Murmansk on 10 April 2015 with different specialists: rescue and police officers, lawyer and economists, geographers and navigators.

Risk matrixes interpret the type perceptions of accidents, which may happen in a certain sea area, and a range of possible consequences. Risk matrixes for Norwegian waters have been created as a result of the analysis of type of events and ship traffic features. It is relevant to consider the following types of events (see Table 16).

TABLE 16 POSSIBLE VARIATION OF ACCIDENTS, DEPENDING OF SHIP TYPE AND EVENTS

	Tourist/Cruise ship	General cargo/tanker vessels/rigs and floaters	Fishing
Grounding	T-G	C-G	F-G
Damage due to collision (sea ice and other)	T-I	C-I	F-I
Fire	T-F	C-F	F-F
Violence/terror	T-V	C-V	F-V
Other reasons	T-O	C-O	F-O

Grounding means the ship hits land or underwater rock. Damage due to collision includes both collision with other vessels/sea installations and sea ice. The category fire is about fire breaking out on board. The category violence means incidents of violent behavior towards persons and physical installations. The category other may include construction failure. On the following risk matrixes red area symbols high risk, yellow – modern, green – low. We also distinguish risk of consequences for the environment and for people (passengers and crew).

TABLE 17 RISK MATRIX OF CONSEQUENCES FOR ENVIRONMENT IN SVALBARD AREA

5 - Frequently					
4 - Relatively frequently		F-G			
3 - Occurs		F-I	T-I,T-G,		
2 - Very Rare		F-O,F-F	T-O,	C-O, C-I,	
				T-F, C-F	
1 - Theoretically possible			F-V, C-V, T-V	C-G,	
	insignificant	minor	moderate	significant	serious

TABLE 18 RISK MATRIX OF CONSEQUENCES FOR PEOPLE (PASSENGERS, CREW) IN SVALBARD AREA

5 - Frequently					
4 - Relatively frequently		F-G			
3 - Occurs		F-I		T-I,T-G	
2 -Very Rare		F-O	C-O, C-I,T-O	F-F	T-F, C-F
1 - Theoretically possible			C-G	F-V,C-V	T-V
	insignificant	minor	moderate	significant	serious

The tables above show that in the Svalbard region, the risk for environment is mostly middle and partly low. For people, the most dangerous events are fire on the major types of vessels and almost all accidents with tourist vessels. Low risk is estimated for grounding incidents with cargo and fire on fishing vessels.

TABLE 19 RISK MATRIX OF CONSEQUENCES FOR ENVIRONMENT IN COASTAL NORWAY

	insignificant	minor	moderate	significant	serious
5 - Frequently					
4 - Relatively frequently		F-G			
3 - Occurs		F-F		C-F	C-G
2 -Very Rare			T-F		T-G
1 - Theoretically possible		F-V			T-V, C-V

TABLE 20 RISK MATRIX OF CONSEQUENCES FOR PEOPLE IN COASTAL NORWAY

	insignificant	minor	moderate	significant	serious
5 - Frequently					
4 - Relatively frequently				F-G	
3 - Occurs				C-G, C-F, F-F	T-F
2 - Very Rare					T-G
1 - Theoretically possible				C-V, F-V	T-V

The tables above show that at the Norwegian mainland coastline, the frequency of grounding and fire among fishing vessels is quite high due to the number of vessels and the vessels operating in most years along a very challenging coastline. There is quite heavy cargo vessel traffic along the coastline, and the probability of grounding was earlier quite high, especially in winter. Better control of vessels' technical quality, increased demands for coastal sailing certificates, pilot services and the Vessel Traffic System (VTS) has reduced the frequency of grounding. For the environment, grounding of cargo vessels and cruise ship, even though they may occur only rarely, may have severe consequences, not at least because of the heavy fuel oil used and a vulnerable coast line with wildlife, fisheries, fish farming, tourist income and leisure activities. Oil spill response may also be severely hampered by bad weather, ice and snow, such as the Full City grounding outside Langesund in Telemark in 2009. The ship had 1100 tons of heavy fuel oil on-board. 200 tons leaked out and approximately 2500 sea birds lost their lives because of this accident. The oil spill response operation took almost one year.

As for risk to life, fire on board ships is a serious threat, not at least on board cruise/tourist ships. The engine room explosion and the following fire on board the coastal steamer M/V Nordlys outside the town of Ålesund in 2011 resulted in two lives lost and 16 wounded. More lives among the 262 persons on-board could have been at stake if the fire had started in heavy weather and far from the nearest harbour. If a grounding occurs with a cruise ship along the Norwegian coast in winter, this may also have severe consequences. As for violent action and terror, the probability may be extremely low. However, the consequences both for lives and the environment may be disastrous.

SUMMARY

Along the coast of mainland Norway and around Svalbard there is a change in traffic patterns connected to petroleum, minerals, fisheries, intra- and inter-regional transportation and research activities. Migrating fish resources, new areas opened for oil and gas activity, increased physical accessibility of the Arctic waters for ships operating in the Svalbard region may increase the number of unwanted incidents, in spite of efforts to reduce the probability through among other stricter regulations. High Arctic conditions that may affect the probability of incidents include poorly charted waters, ice and icing, unpredictable weather, and darkness in winter. Seasonal changes in the High Arctic are dramatic and difficult to foresee. They influence on the commercial activity as well as the consequences of accidents. Lack of experience, navigational competence and crew fatigue is human-related risk-shaping factors that increases with operations in the autumn and winter months. There are limited capacities for mitigating the consequences of large-scale accidents including many persons, or pollution from large dangerous goods spills to sea. This means that the consequences may be more severe in case of accidents involving larger vessels such as oil rigs and cruise vessels. The oil and gas industry has an obligation to do thorough risk assessments and build up their own SAR and oil spill response capacity. This is not the case for the cruise industry. This means that the government has to do more thorough risk assessments and consider the need for emergency capacities in the areas where cruise vessels are most frequent.

The coastal sea traffic in Norway includes passenger and cargo transport and highly interlinked with different commercial activity in the region. Traffic includes vessels of 55 different nations, where 39% are Norwegian. The most traffic includes fishing vessels, cargo ships and tankers. The main four groups of vessels in the Svalbard area are tourist, cargo, research and fishing vessels. The cruise ships dominate as to number of people, but the fishing vessels largely dominate by numbers. Most of the incidents happen in the areas between mainland Northern Norway and Svalbard, even though total numbers shows that mostly incidents happen in coastal sea areas of Northern Norway and about half of the reported accidents are occupational accidents.

Oil spills and life-threatening accidents with large cruise ships are the most discussed events due to the consequences and the limited preparedness capacity for search and rescue, hospital care and oil spill response. The density of maritime traffic in the coastal Norway may increase the probability of oil spill due to grounding and collisions. The vessels operating all year round have the highest risk in this case. There is a cargo vessel traffic along the coastline all year round, and the probability of grounding is quite high, especially in winter. The frequency of grounding, leakages and fire in the fishing fleet is quite high due to the number of vessels, and the vessels operating during the autumn and winter months under harsh conditions. With more large-sized cruise vessel arrivals along the Norwegian coast in the months with challenging weather conditions and darkness, we may experience changes in the risk pattern towards significant higher risk levels.

PART III MARITIME ACTIVITY RISK PATTERNS AND TYPES OF UNWANTED INCIDENTS. THE ICELANDIC SEA AREAS *BY VALUR INGIMUNDARSON AND HALLA GUNNARSDÓTTIR*

This report identifies current risks and vulnerabilities with respect to preparedness capacity in the sea around Iceland. First, it analyses the dominating risk factors. Second, it estimates the probability of life or environment threatening incidents. Third, it looks into the consequences of possible maritime incidents. Fourth, it offers a risk assessment for different incidents in the Icelandic Search and Rescue Region (SRR). Finally, it discusses new policy and legal challenges related to maritime activity and security.

Iceland's maritime preparedness system aims at preventing and assuring fast response to any accidents on sea, which pose risks to human lives or the environment. The Icelandic Coast Guard (ICG) is the key operational actor responsible Search and Rescue (SAR) and protection against unlawful accidents. In the event of incidents that threaten the environment, the Environment Agency is the central authority, while the ICG would act in an operational capacity. The National Commissioner of the Icelandic Police (NCIP), however, is in charge of tactical police operations at sea.

1 DOMINATING RISK FACTORS

The main vulnerabilities for maritime traffic in the sea around Iceland are: (1) weather conditions; (2) ships' condition and equipment; (3) risk of fire; and (4) risk of human mistakes or errors in decision-making.[2] Within the entire Search and Rescue Region of Iceland – which is 19 times the size of the country itself –higher temperatures have led to increasing drift ice. This can cause severe accidents, resulting in threats to human lives and to the environment.

While some cruise vessels are not equipped for harsh sea conditions,[3] most of them are relatively new and considered suitable for the Arctic. The cargo vessels and tankers fleet have, on the other hand, come of age and are not in as good condition. Competition and pressure for lower prices have resulted in some companies using older vessels and under-paid (and under-trained) crews. Every

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[2] "Summary of Cruise Vessels Safety at Faxaflóahafnir". 2012

[3] Risk Assessment for Iceland: Global, Societal, and Military Factors." Prepared by a commission under the chairmanship of Prof. Valur Ingimundarson, March 2009. English Summary available at: http://www.mfa.is/media/Skyrslur/A_Risk_Assessment_for_Iceland_-_English_Summary.pdf

week, the ICG interferes with vessels that are not equipped or operated in accordance with mandatory standards. This can pose a great risk to the lives of crewmembers and rescuers and to the environment. Needless to mention, under-trained crewmembers are more likely to make wrong decisions under pressure, which, again, increases the likelihood of accidents. The same can be indicated about tired and overworked crewmembers. A case in point is the grounding of Akrafell east of Iceland in September 2014, where the navigation officer had fallen asleep. Owing to good weather, the crew was saved and pollution prevented, but the vessel was damaged.

The case of Akrafell also revealed certain weaknesses in the Icelandic preparedness system due to budget cuts, resulting from the 2008 financial crisis in Iceland. Only one patrol vessel, Ægir, was available, and it took an extra effort to gather a crew for Þór, which was in port in Reykjavík. The ICG's airplane, TF-SIF, was located in Iceland to monitor the volcanic eruption in Bárðarbunga, but is usually abroad on funded projects at this time of the year. The plane is equipped with maritime radar that can detect pollution fast and accurately, and did so in this case. The Akrafell operation was successful, but the lack of manpower and the absence of the ICG's airplane, helicopters and patrol vessels could pose future challenges in similar situations.

Grounding and ship fires are well-known risk factors. Priority is given to human safety followed by measures to pre-empt environmental accidents, which can include preventing the distressed vessel from burning completely down. Finally, the operation aims at salvaging the vessel or other properties at stake.

If oil production at the Dreki area North East of Iceland will commence, it will add factors that can pose risk to human lives and the environment. This includes: 1) sudden incidents related to oil drilling; 2) incidents related to production, such as a broken pipeline (which could go unnoticed for a while); and 3) accidents related to vessel traffic. However, the current activity level in the area is very low and will remain so in the next 10–15 years.

2 ACTIVITY AND PROBABILITY OF INCIDENTS

Fishing vessels make up the largest part of maritime traffic in the sea around Iceland. Traditionally, fatal accidents on sea prevail in the area, but their number has decreased drastically in the past decades from an average of 20 a year in the 1970s to 2 in the first decade of the 21st century. In relation to the shrinkage of the fishing fleet, the decrease is still significant. This progress can among other reasons be explained by the improved safety surveillance, better-equipped vessels and lifeboats, and mandatory safety and survival training for seamen.[4] Fatal accidents are, however, not the only concern for seamen. Injuries and illnesses can be life-threatening since it may take long time to get medical aid. Illnesses are hard to predict, but owing to better equipment, injuries from accidents are less likely to occur than before.

As for the risk of fire, the ICG normally deals with a few, mostly minor incidents on sea each year, frequently relying on assistance from the Capital District Fire and Rescue Service. While improved preventions decrease the likelihood and the harm of fire, such incidents are always to be expected. The operations are rarely as difficult as the massive fire that broke out in the engine room of MV Fernanda in the fall of 2013, south of the Westman Islands (Vestmannaeyjar). The crew of 11 failed to extinguish the fire and, eventually, gathered on the vessel's deck where an ICG's helicopter came to rescue. After fighting the fire, the vessel was towed away from fishing areas into Hafnarfjörður port in the southwest of Iceland. When entering the port, it was discovered that the fire was still alive, and the smoke spread over residential and commercial areas. Fernanda was brought back to the open sea, as far away from fishing and spawning areas as possible, to continue the fire fighting and cooling process. Five days later, and seven days after the fire, Fernanda was towed to the southwest port of Grundarfjörður and, eventually, it was brought to Helguvík on the Reykjanes peninsula for demolition.

The grounding of the containership MV Vikartindur in 1997 and of the Cypriot bulk carrier Wilson Muuga in 2006 sparked a debate over sea safety, sea routes, and pollution prevention around Iceland. In the case of Vikartindur, the ship's captain refused to receive assistance until an hour before the ship, whose engine was dead, grounded at the south coast of Iceland. The rescue operation resulted in the death of an Icelandic Coast Guard's rescue man. Pollution was prevented, but it turned out to be a demanding task to clean up the coastline. In the wake of this event, the legal framework was revised to guarantee the right of Icelandic authorities to intervene in case of a life or environment-threatening situation. The rescue operation of Wilson Muuga, which also resulted in the death of a rescue man from a nearby Danish patrol vessel, was administratively simpler, however, harsh

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[4] See e.g. http://www.visindavefur.is/svar.php?id=65017 and http://imh.mug.edu.pl/attachment/attachment/1326/2007_x04.pdf

weather conditions made pollution prevention difficult to manage.

Legal amendments were subsequently made to guarantee the maximum financial responsibility of shipping companies in cases of grounding or environmental accidents. Cooperation canals between the Icelandic Coast Guard and the Environmental Agency were reviewed and emergency ports were identified in different places around the country. Finally, a new regulation on sailing routes south and southwest of Iceland, where most of the maritime traffic is directed, entered into force. An earlier attempt to pass such regulation had failed due to the opposition of shipping companies.[5]

According to the regulation, approved by the International Maritime Organization (IMO) in July 2007, ships are only allowed to use certain routes in the area, depending on their size, cargo and capacity. The main aim is to guarantee the most secure sailing routes and to limit the likelihood and harm of pollution accidents.[6] Grounding is, therefore, less likely than before to pose a threat to human lives and the environment. Ships are obliged to notify port authorities on possible sea pollution and polluting accidents (if more than 100 l. of polluting materials are discharged to the ocean). In Faxaflói, there is an average of 3–4 reported pollution incidents each year, but so far, none of them has been serious.[7]

As for illegal activities, several drug smuggling attempts have been prevented in Iceland's Exclusive Economic Zone (EEZ). The threat of a terrorist attack in Iceland is considered low, and there have been no signs of such activities.[8] However, according to a recent risk assessment, performed by the National Commissioner of the Icelandic Police, members of ISIS (the Islamic State) have passed through Iceland on way from North America to the Middle East. The police also reports that ISIS

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[5] "Áfangaskýrsla starfshóps um leiðastjórnun skipa, neyðarhafnir og varnir gegn mengun frá siglingum" (Progress Report on Sailing Routes, Emergency Ports and Marine Pollution Prevention). 2007. Siglingastofnun. Retrieved from http://ww2.sigling.is/lisalib/getfile.aspx?itemid=3365

[6] "Progress Report". 2007

[7] Faxaflóahafnir Associated Icelandic Ports Annual Reports 2006-2013. Retrieved from http://www.faxafloahafnir.is/category/is/fyrirtaekid/arsskyrslur/

[8] "Risk Assessment for Iceland: Global, Societal, and Military Factors." Prepared by a commission under the chairmanship of Prof. Valur Ingimundarson, March 2009. Available in Icelandic at: http://www.utanrikisraduneyti.is/media/Skyrslur/Skyrsla_um_ahattumat_fyrir_Island_a.pdf. English Summary available at: http://www.mfa.is/media/Skyrslur/A_Risk_Assessment_for_Iceland_-_English_Summary.pdf. and Proposal of a Parliamentary Committee for the development of National Security Policy for Iceland." February 2014. Unofficial English translation available at: http://eeas.europa.eu/delegations/iceland/documents/press_corner/20140324_en.pdf.

propaganda may encourage individuals to commit serious crimes in Iceland.[9] This threat is, however, still considered low.

Following the 2007 decision to resume whaling, Iceland has, again, become under intense scrutiny by animal protection organizations. While the campaign for animal welfare is, in general, peaceful, there are examples of sabotage and vandalism. Recent examples are found in Japan. As for Iceland, one historical case should be mentioned: Members of the Sea Shepherd environmental organization sank two whaling ships in the port of Reykjavík in 1986. No one was injured, but according to the whaling company, damages were estimated of $2 million.10

3 CONSEQUENCES OF DIFFERENT INCIDENTS

Risks to Human Lives

In the event of serious accidents or illnesses at sea, the long distance to medical services poses risks to seamen. In one recent instance (September 2014), it took over ten hours to transport an injured seaman from *Reykjafoss*, 500 nm southwest of Iceland. Assistance was requested from the Danish patrol vessel *Triton*, which was located 285 nm from *Reykjafoss*. The two vessels steamed towards each other until *Triton's* helicopter was able to fly to *Reykjafoss*. The helicopter, then, had to return to *Triton* to refuel and wait until the distance to land was within the flight range limits.

While most large passenger ships and cruise vessels would have essential medical services on board, there are risk factors that have to be taken into account. Should an accident – whether related to fire, grounding or something else – involve more than one person, the challenges become much greater. In the event of a ferry or cruise vessel accident, it could take days to deport hundreds or thousands of people by helicopters and lifeboats to land, and even longer if people are injured. The average sea temperature in Reykjavík is at its highest in July, or little above 11°C, while in March, it is only 5°C.[11] The chances of surviving a long time in such a cold sea are poor. If an accident takes place

[9] "Mat ríkislögreglustjóra á hættu af hryðjuverkum og öðrum stórfelldum árásum" (NCIP Assessement on the Risk of Terrorism and other Large Scale Attacks). February 2015. Ríkislögreglustjóri. Retrieved from http://www.logreglan.is/wp-content/uploads/2015/02/Mat-r%C3%ADkislögreglustjóra-á-hættu-af-hryðjuverkum-og-öðrum-stórfelldum-árásum.pdf

[10] See e.g. http://www.nytimes.com/1986/11/20/world/around-the-world-whaling-ships-refloated-in-iceland.html

[11] See e.g. http://www.seatemperature.org/europe/iceland/reykjavk.htm

north of Iceland, but within the Icelandic Search and Rescue region, the chances of people surviving the cold become even lower. It is estimated that people can stay for 15–30 minutes in such a cold sea before exhaustion or unconsciousness.[12]

Conditions for rescue operations are very difficult north of Iceland and in the Greenland Sea. Lack of infrastructure increases the level of difficulty. There are, for example, no harbours along the east coast of Greenland and only a couple of gravel airports. The closest medical services are to be found in Iceland. Additionally, telecommunications are very poor in the area. Given the current rescue capacity, it would be impossible for the Icelandic Coast Guard to rescue a large number of people from a cruise vessel in the area.[13] This scenario was, as a matter of fact, the central theme of the Arctic Council's SAREX Greenland Sea in 2013. The exercise centered on a 250 passenger cruise ship in distress in the Arctic Sea, northeast of Greenland, within the Search and Rescue Region of Iceland. The results of SAREX highlighted the difficulties of large rescue operations in the area. A SAREX follow-up desk exercise, which took place in October 2014, focused on transporting people from the Greenland Sea to Iceland for medical care. In such an event, the civil protection system needs to be activated with participation of health authorities and border control.

Environmental Risks

A Committee for the Development of a National Security Policy for Iceland has defined environmental threats, sea pollution, or accidents due to increased maritime traffic in the Arctic as key risks for Iceland because of its dependence on fisheries.[14] The main sailing routes around Iceland are close to mayor fish spawning areas and important fishing grounds.

While the 2007 regulation on sailing routes south and southwest of Iceland decreased, the likelihood of severe harmful incidents, such as a pollution accident could have serious, detrimental consequences. An oil spill could cause harm in shallow sea or on the coast, with cleaning operations

[12] See e.g. http://www.seagrant.umn.edu/coastal_communities/hypothermia
[13] "Risk Assessment for Iceland". 2009
[14] "Proposal of a Parliamentary Committee for the development of National Security Policy for Iceland". February 2014. Unofficial English translation available at: http://eeas.europa.eu/delegations/iceland/documents/press_corner/20140324_en.pdf

set to be both expensive and time-consuming.[15] The main Icelandic harbours are equipped to handle oil spill or other forms of sea pollution. In this context, oil tankers do not pose the greatest environmental risk in the ocean around Iceland since they do only carry oil and diesel. Crude oil, on the other hand, is far more hazardous, and it is on board in most cargo vessels.

The Icelandic Coast Guard's vessel *Þór* (2011) is equipped with a 300 m oil boom and an oil skimmer. Before the acquisition of *Þór*, Iceland did not own any equipment to deal with environmental accidents on the open sea. Nonetheless, in the event of a pollution accident within the EEZ of Iceland, it could take up to 46 hours for *Þór* to reach the scene.[16] In the event of a large accident, the Environment Agency, which is administratively responsible for oil recovery, can request assistance from the Nordic countries on grounds of the Copenhagen Agreement[17] and from the European Maritime Safety Agency (EMSA). EMSA has a network of stand-by oil spill response vessels, available to assist in oil recovery and pollution prevention operations. Additionally, EMSA provides organizational and co-ordination support. While international assistance would be essential for Iceland in emergency cases, it could take the vessels a few days to reach the scene, depending on the location. Iceland would, therefore, have to rely on the ICG's *Þór.*[18]

4 RISK ASSESSMENT

The following risk assessment for the Search and Rescue Region of Iceland evaluates the probability of different incidents and the level to which each incident can pose risk to people or the environment. The assessment is based on written reports of previous incidents and evaluation by experts from the Icelandic Coast Guard and the Environment Agency. It is important to note that the assessment is based on general estimation and does, therefore, not offer precise prediction of possible incidents in the Icelandic SRR. On the other hand, the risk assessment can serve as a basis for further analysis of dominating risk factors within the Icelandic Search and Rescue Region. The assessment is done for the whole region, as the risk factors are similar. However, given that vessel traffic is at higher level

[15] "Progress Report". 2007, p. 45
[16] "Progress Report". 2007, p. 77
[17] See http://www.copenhagenagreement.org/
[18] "Progress Report". 2007, p. 59-61

South and Southwest of Iceland, accidents are more likely to take place in that area.

The possible incidents for the Icelandic SRR have been identified as follows:

Grounding & mishap refers to an incident where a ship hits land or underwater rocks or when a ship capsizes,

Collision refers to damage due to collision with other vessels or ice,

Fire/explosion covers any fire or explosion on board,

Violence/terror refers to terrorism or violence against people at sea,

Sabotage/vandalism refers to damage done by people on vessels or installations.

The incidents are further identified with respect to the different types of vessels, as demonstrated in table below.

TABLE 21 POSSIBLE VARIATION OF ACCIDENTS, DEPENDING OF SHIP TYPE AND EVENTS

	Passenger vessels (incl. cruise vessels)	Cargo/tankers	Fishing vessels
Grounding & mishap	P-G	C-G	F-G
Collision (incl. ice)	P-I	C-I	F-I
Fire	P-F	C-F	F-F
Violence/terror	P-V	C-V	F-V
Sabotage	P-S	C-S	F-S

The risk matrix evaluates the probability of the identified incidents and the possible consequences for a) the environment and b) people (passengers and crew). The risk is considered high if the probability of the incident is high and the consequences serious. The red cells indicate high risk, the yellow are moderate risk and the green suggest low risk.

Possible Consequences for the Environment

TABLE 22 RISK MATRIX: PROBABILITY OF INCIDENTS AND CONSEQUENCES FOR ENVIRONMENT IN THE SOUTHERN AND WESTERN PART OF THE SRR OF ICELAND

	Insignificant	Minor	Moderate	Significant	Serious
5 – Frequently					
4 – Relatively frequently					
3 – Occurs		F-F	F-G, F-I, P-G, C-F, P-F,		
2 – Very rare			C-I, P-I, C-G		
1 – Theoretically possible			F-V, F-S, P-V, P-S, C-V, C-S		

Table 22 demonstrates that all the factors pose moderate risk to the environment. The severity is still highly dependable on: 1) where the incident happens; 2) if it leads to oil spill or other pollution; 3) how much polluting material is on board; and 4) what sort of vessel is involved. Consequences for the environment are usually more severe closer to land, where pollution recovery is both difficult and time-consuming. The ocean south and southwest of Iceland is also more vulnerable to pollution, as it is home to major fish spawning areas.

All the identified incidents can lead to oil spill. Any incident involving large cargo or cruise vessel – which can carry as much oil as an average oil tanker – can pose a great risk to the environment. On the other hand, these vessels are generally well equipped and the crews well trained. The ships that have grounded or collided in the sea around Iceland have generally been smaller fishing vessels and older cargo ships that are not sailing according to a regular schedule. Large cruise vessels have not grounded around Iceland, but there have been incidents with smaller passenger boats. Fire can come up in all different vessels and can pose minor to moderate threat to the environment, if it leads to explosion or oil spill. No incidents of terrorism have been reported in the Icelandic SRR, but such violence remains theoretically possible, mainly for passenger ships or – less likely – cargo vessels. Whale hunting boats might be more likely to be a target of vandalism by animal protection activists, but such incidents only remain a theoretical possibility. The level of risk would depend on the type of terrorism/sabotage. Sabotage could, for example, lead to oil spill and terrorism could involve sinking a ship.

Should an incident involve a large vessel, it is obvious that the consequences could be very severe for the environment. But in general, the likelihood of such an incident is not very high, which explains why most risk factors are considered moderate in this matrix.

Possible Consequences for People

TABLE 23 RISK MATRIX: PROBABILITY OF INCIDENTS AND CONSEQUENCES IN THE SOUTHERN AND WESTERN PART OF THE SRR OF ICELAND

5 – Frequently					
4 – Relatively frequently					
3 – Occurs				F-G, F-I, F-F, C-F, P-G,	P-F
2 – Very rare				C-G, C-I, P-I,	
1 – Theoretically possible				F-S, C-S, P-S	F-V, C-V, P-V
	Insignificant	Minor	Moderate	Significant	Serious

Table 23 shows that all different incidents may have significant or serious consequences for human lives. The potential for each incident is the same as in table 2, but the risk to human lives is different than to the environment. The level of risk for each incident would depend greatly on: 1) where the incident happens; 2) how many people are on board; 3) the training of the crew; 4) weather conditions and sea temperature; and 5) available life-saving equipment. Extreme weather can make rescue operations very difficult and even pose risk to the lives of rescue people. Such operations may also be more time-consuming farther from land and, therefore, pose greater threats to human lives.

Fire can be particularly dangerous on passenger ships, as there are more people on board. The larger cruise vessels would, on the other hand, be better equipped to deal with outbreaks of fire. In any case of grounding or collision of large cruise vessels, rescue operations could prove to be very difficult. However, the likelihood of such incidents remains low.

Terrorism would always pose great risk to human lives. Sabotage could also threaten people's lives, but depending on what kind of sabotage or vandalism it would be.

NEW CHALLENGES

While improved technology has simplified surveillance and rescue operations, the preparedness system has also been faced with new challenges. As noted, the intervention authorization of the ICG and the Environment Agency were strengthened after the case of *Vikartindur*, where the vessel's captain refused assistance until it was too late to prevent grounding. This legal right was, for example, exercised in the case of the grounding of *Green Freezer* in 2014. The owner's original plans, to use a tugboat to refloat the vessel, proved to be unrealistic.

The case of *Fernanda* has raised additional questions about the legal issues, underpinning rescue operations. The ship was registered in the Commonwealth of Dominica and insured in Russia. The ship company, which owned Fernanda, was registered in Estonia, but it was operating for an Icelandic ship company. Additionally, the crew was of different nationalities and none of them from Estonia or Dominica. During the rescue operation, it proved difficult to get hold of the ship's owners and/or the insurance company. The insurance company subsequently refused to pay for the operation, claiming it was unnecessary to tow the ship away from the original place where it caught fire. The ICG started legal proceedings, which resulted in a settlement where the costs of the ICG were fully covered.

The increased activities of private, marine salvage companies, has raised additional questions. Contracted (or looking to be contracted) by insurance companies or ship owners, the salvagers want to overtake operational management on scene. Three different actors, it turned out, were preparing to take control of operations around the grounding of *Akrafell* in 2014. While some salvage companies are experienced in different marine conditions, it can take time for them to arrive with the necessary equipment and to provide realistic plans. This again can create conflicts concerning operational management as well as disputes on the salvage award.

The increasing international nature of the shipping industry provides challenges for local authorities. Operating in a somewhat new landscape, both the ICG and the Environment Agency emphasize the need for additional capacities and resources to guarantee full refund of any operations related to pollution prevention and oil recovery. In any case, the intervention authority of governmental institutions is essential to be able to take control on scene and prevent marine pollution.

SUMMARY

The Icelandic preparedness system and its response mechanisms do not face major problems. The agencies involved in Search and Rescue have sought to draw lessons from previous incidents in the sea around Iceland and from regional exercises as part of their efforts to strengthen their capacity to deal with different contingencies. The risk factors for maritime activity remain the same. But owing to better vessels, security equipment, improved technology, and safety and surveillance training, the preparedness system is more capable of responding to life threatening incidents than before. The Icelandic Coast Guard has, however, not been able to realize the full potential of its resources due to budgetary restrains, a development that can affect its surveillance function and increase response time in case of accidents.

Meanwhile, new trends in the international shipping industry have created new challenges, particularly with respect to administering pollution prevention and salvage operations. Key governmental institutions still lack the power to take all measures considered necessary to prevent marine pollution and to assure full refund of the salvage operations.

Given the enormous size of the Icelandic Search and Rescue Region, Iceland would always need to rely up on international assistance in the event of large accidents. Rescue actors, as well as ship companies, need to be familiar with the difficult marine conditions in the sea around Iceland, particularly north of the country and east of Greenland where infrastructure is limited. Regional exercises and operational cooperation are essential to guarantee the most professional response to any regional incidents.

PART IV Maritime Activity Risk Patterns and Types of Unwanted Incidents. The Greenlandic Sea Areas *by Uffe Jakobsen* and *Bolette Kern*

The MARPART project studies the time period from 2015 to 2025, which means considerations concerning e.g. off-shore installations and which sea routes will be accessible in 2025. Such developments are, of course, very hard to predict, especially because the nature in the Arctic is very unpredictable. Already in 2007, the European Space Agency announced that the Northwest Passage for the first time was open to traffic. According to UN's IPCC's fourth evaluation report the Northwest Passage will continue to be free of ice during summer season the next decades (Stuer-Lauridsen & Overgaard, 2013; p. 38). Meanwhile, before 2025 there is no expected increase in container or cargo vessels sailing through the Northwest Passage due to season changes, ice blocking, insufficient nautical charts and limited draught (Stuer-Lauridsen & Overgaard, 2013; p. 39).

An estimate of maritime activity is also hard to make. In the case of Greenland the coastal maritime traffic is serving a small population and a small industry which is neither expected to grow significantly the coming years, nor the maritime traffic is expected to increase. There have been and will be test drillings for oil and minerals, but none of these projects are sufficiently large to predict an increase in the maritime activity. At the moment the only active mine in Greenland is the ruby mine in Aappaluttoq near Qeqertarsuatsiaat on the Greenlandic midwest coast, which is a relatively small mine. Also at the moment a public consultation is in process for the Ironbark application concerning the exploitation of the zinc/lead deposits at the Citronen Fjord in North Greenland National Park. In the Environmental Impact Assessment report Ironbark has assessed that shipping according to this project will not have impact on the environment, since shipping is done outside the breeding season of ringed seal, and the low frequency of maritime journeys expected in the three months window (Naalakkersuisut, 2015).

In the MARPART project *Report 1: Maritime Activity in the High North – Current and Estimated Level up to 2025* we have highlighted that Greenland's size and location in the Arctic are causing some challenging circumstances when it comes to maritime activity. Greenland's territorially large area covers both a large land and sea area, and hereby also an extensive coastline. Around 85 per cent of Greenland is covered with permanent ice, and the weather is heavy and unstable and often unpredictable. The coastal waters of Greenland are partly ice covered or marked by icebergs and pack ice. Greenland is sparsely populated and the population is living scattered on the remaining 15 per cent of the island not covered by ice. Due to the large distances, dispersed population, rough geography and harsh climate infrastructure is only available in the populated areas. This means that few harbours, heliports and airports are placed along the very extensive coastline.

Climate changes have induced possibilities in the Greenlandic waters that already have, and in the future will have, large influence on the maritime activity and traffic in Greenland. More traffic is due to longer sailings seasons, which affects all maritime vessels, but not least fishing vessels. Offshore oil and gas as well as mining industries will lead to an increase in maritime activity and traffic. Greenland is already seeing an increase in the number of cruise ships as Greenland and the Arctic have become a desired tourist attraction in general and especially a destination for large cruise ships.

The increase in the maritime activity that Greenland already has experienced and is expecting in the future is generating risk factors for potential unwanted incidents when considering the special circumstances present in the Arctic and Greenlandic nature.

1 DOMINATING RISK FACTORS

On the basis of the conclusions from *Report 1: Maritime Activity in the High North – Current and Estimated Level up to 2025* four potential threatening situations is selected for further examination and analysis in this report. Grounding is a dominating risk factor due to the very extensive Greenlandic coastline with many underwater reefs and comprehensive skerries. Also the presence of ice in the Greenlandic waters is a risk factor due to ships' collision with the ice. These two potential threatening situations are intensified and complicated by the position of a potential accident and the characteristics of its surroundings. The Arctic and Greenlandic nature and climate entail surroundings that are unpredictable and unstable often in form of heavy weather and ice, which complicate search and rescue operations and environmental control. Also the position of a potential accident is a dominating risk factor due to the much dispersed infrastructure. Most of the airports and heliports are centered close to the most populated areas on the southwest and midwest coast of Greenland; this creates a risk factor for those ships operating far away from the west coast in remote and isolated areas. Due to the increased focus on the expected presence of minerals in the Greenlandic subsoil and the oil and gas deposits of shore Greenland, both environmental activists and wildlife activists have been more present in Arctic and the Greenlandic waters. This increase constitutes a risk of violence and even terror against mineral or oil companies. These four threatening factors are composed of the most dominating risk factors to maritime activity and traffic in Greenland, and they will be analysed in the next sections.

2 ACTIVITY AND PROBABILITY OF INCIDENTS

The section below presents only the number of search and rescue operations, partly because until august 2015 no known oil spill or pollution in general has taken place in Greenlandic waters, and partly because there have not yet been made estimations on the environmental risk.

SEARCH AND RESCUE

In case of an incident in Greenlandic waters, that requires search and rescue (SAR), these operations are provided by several actors. The responsibility for SAR operations is divided between the Greenland Police, which is a Danish institution, who are handling SAR operations within a zone of 3 nautical miles from the coast, and the Danish Defence's Joint Rescue Coordination Centre (JRCC) that is handling SAR operations in an area between the 3 nautical miles line from the coast to the outer limit of Greenland's area of SAR responsibility, according to the SAR agreement made under the auspices of the Arctic Council in 2011, see figure 9.

FIGURE 9 KINGDOM OF DENMARK'S SAR DELIMITATION (SOURCE: ARCTIC PORTAL LIBRARY)

A large part of the SAR operations is conducted in cooperation between the Greenland Police and JRCC. JRCC is furthermore responsible for ships reporting to the GREENPOS system, no matter where the ships will be within Greenland's area of SAR responsibility. JRCC is a cooperation between two actors: the Joint Arctic Commando (JAC) which surveys the maritime traffic and Naviair that observes the air traffic.

Every year the Operative Kontaktgruppe Arktis (OKA) completes a report on all SAR operations in Greenland, both local SAR operation conducted by the police and those conducted by the JRCC. This report is used here as a source to describe the probability of accidents in Greenlandic waters.

TABLE 24 NUMBER OF SAR OPERATIONS 2009-2014

	2009	2010	2011	2012	2013	2014
SAR sea	27	60	82	84	95	75
SAR land	2	4	5	21	22	20
SAR air	3	1	1	1	3	2
Total	32	65	88	106	120	97

SAR operations include all incidents from distressed vessels, airplanes and persons in water or on land. SAR operations on land are most often hunters in trouble, but also expeditions on the ice cap, mountaineers or other events. A SAR operation concerning air includes destitute persons and emergency landing.

First, the number of SAR operations must be compared to the number of journeys and not the number of vessels, since a SAR operation is tied to the individual journey and not the individual vessel. Second, the number of journeys is not estimated. This is probably because the number of vessels and their journeys in Greenland is based on registrations in GREENPOS, which only constitute the reported number of ships. In general, these are vessels under 30 feet that not, or very rarely, register in GREENPOS (Joint Arctic Command, 2015: 9).

TABLE 25 NUMBER OF PERSONS IN DISTRESS 2009-2014

	2009	2010	2011	2012	2013	2014
Persons	71	199	233	263	348	223
Missing	1	8	3	0	6	5
Perished	3	2	0	3	2	10
Rescue percentage	94,4	95	98,7	98,8	97,7	93,3

According to the aims of *Skibsfartens og Luftfartens Redningsråd* the rescue percentage should be 94 percent and over, which is fulfilled in all years but 2014. The lower rescue percentage in 2014 is due to especially two lager incidents in 2014, with a larger number of perished persons[19]. It should be emphasised that the aim of an a rescue percentage of 94 percent is not an indication of an acceptance of the loss of up to 6 persons out of every, but an indication that a rescue percentage of 100 percent is unrealistic. Sometime people deliberately don't want to be rescued (Joint Arctic Command, 2015; 6).

TABLE 26 TYPE OF MARINE VESSELS IN SAR OPERATIONS

	2009	2010	2011	2012	2013	2014
Maritime vessel under 30 feet						
Dinghy/motor boat	18	40	65	49	70	64
Sailing ship	0	0	0	0	5	1
Kayaks	0	2	0	0	0	1
Other	0	0	0	1	0	0
Maritime vessel over 30 feet						
Motor boat	0	0	2	12	1	0
Cargo vessel	0	2	1	3	0	0
Tugs	1	0	0	0	0	0
Sailing ship	1	4	2	2	6	1
Fishing vessel	3	7	4	16	2	2
Tanker	1	0	0	0	0	0

[19] In august 2014 four people perished in an accident in the Disco Bay area. Also, in July 2015 three people perished close to Uummannaq.

Marine vessels under 30 feet constitute the largest number of SAR operations, especially dinghies and small motor boats account for most SAR operations. JSCC Greenland has experienced in the recent years that the many incidents with small boats under 30 feet are due to an increase in prices on traffic traveling by air plane or ship, why people take the chance and sail by them self to various destinations on the coast (Joint Arctic Command, 2015: 8). Insufficient information on where people travel by boat, on when they expect to be back plus poor equipment and bad motor maintenance led to a campaign up to the sailing season 2014 with focus on informing on the necessity of a check-up on the motor ahead of sailing trips. Earlier SAR service has had success with reminding sailors to remember sufficient fuel for the whole trip and coloured tape that easily can be seen by the SAR service (Joint Arctic Command, 2015: 8).

TABLE 27 AREA FOR SAR OPERATIONS AND NUMBER OF INCIDENTS

	2009	2010	2011	2012	2013	2014
East Greenland	4	9	10	13	16	10
Southwest Greenland	16	26	34	47	41	34
Midwest Greenland	7	15	19	19	27	34
The Disco Bay area	5	6	18	16	24	10
Northwest Greenland	9	9	7	11	12	9

Most of the SAR incidents are occurring on the west coast of Greenland, and especially southwest Greenland. This is due to the location of several towns on the west coast compared to the two on the east coast. Much of the maritime activity and traffic is going on in between towns on the west coast.

To sum up, dinghies and small motor boats under 30 feet most likely owned by individuals and self-employed fishermen are the most common vessel types in the Greenlandic waters and also that type of vessel which accounts for most SAR operations. The largest part of SAR operations to marine vessels over 30 feet is concerning fishing vessels and larger motor boats, whereas cargo vessels, tugs, sailing ships and tankers rarely need help from SAR operations.

Cruise ships

There has not been any accidents involving larger cruise ships in Greenlandic waters, and this type of ship are therefore not represented in OKA's report on SAR operations in Greenland. The number of cruise ships sailing in Greenlandic waters has increased since 2009, and in 2014 92 cruise ships sailed in Greenlandic waters (MARPART Report 1, p. 20). The number of passengers has fallen from 26.976 in 2009 to 20.216 in 2014, because less high-capacity ships with over one thousand passengers are cruising Greenlandic waters, whereas several smaller cruise ships with 200-500 passengers more often are sailing in Greenlandic waters.

We can make no estimate on how likely it is that a cruise ship will end up in an accident and in need of help, but cruise ships are very present in the Greenlandic waters, and probably will be more present in the future, and considering the large number of passengers despite the fall in the number of passengers, an accident could be fatal.

Pollution response preparedness

First, it should be emphasized that until august 2015 there has not been any known oil spill or other environmental pollution. In august 2015 an oil spill on the Greenlandic east coast was observed by the Joint Arctic Command. This accident is further described below in this section.

Table 4 tells that most SAR operations and accidents happen on the west coast of Greenland, especially Southwest and Midwest Greenland and in the Disco Bay area. In these areas the level of maritime traffic is higher than in the rest of Greenland, and the traffic routes in the region are located close to shore. The more traffic the greater the risk of accidents and the need of SAR operations or/and risk of environmental pollution response, so the west coast of Greenland, and especially the areas around the larger towns, is estimated to be in greater risk of oil spill or other forms of environmental pollution.

The Greenlandic institutions for preparedness to oil spill response is the company Greenland Oil Spill Response (GOSR), owned by the Government of Greenland, which is operating from Nuuk and Aasiaat. GOSR is in control of quite a large amount of equipment for handling oil spill, e.g. different oil boomers for harbours, open water and beaches and oil skimmers (www.gosr.gl). GOSR's equipment can handle quite a serious oil spill. In 2014 GOSR's response equipment was moved from the airport area in Kangerlussuaq to the harbour areas in the towns of Nuuk and Aasiaat in order to ensure a better coverage of the whole country and faster mobilisation by sea (Greenland Oil Spill Response, 2015: 5). Even though the response equipment is available in Nuuk and in Aassiat there is still a question on how fast the equipment can arrive at a possible waste site. In 2015 The Joint Arctic Command registered an oil spill on the east coast of Greenland, and sent a ship to investigate the oil spill. Due to the large distance from the location of the ship to the location of the presumed oil spill pollution and due to bad weather the ship reached the oil spill five days after the oil spill was first observed via satellite images, an amount of time that has been criticised by Greenpeace, who criticise the Greenlandic preparedness for not being efficient (Greenpeace, 2015). In general the National Audit Office of Denmark criticizes the Danish Defence for not prioritizing surveillance of the Greenlandic marine environment, lacking assessment of the environmental risk and legislative enforcement in the area (Rigsrevisionen, 2013: 25).

On the basis of the criticism from the National Audit Office of Denmark and expected increase in the maritime activity and traffic in Greenland, it was agreed in the Danish Defence Agreement 2013-2017 that a risk assessment should be prepared for the marine environment in and around Greenland. The risk assessment must contribute to the assessment work concerning the Danish Defence's consolidation of assignments in the Arctic (Danish Defense Agreement 2013-2017). The report on the environmental risk assessment in Greenland will make estimations on the combination of the vessel traffic data, historical accidents data and estimation on the likely spill volumes.

GEUS – *Geological Survey of Denmark and Greenland* – has in very rich detail described exactly which area in Greenland there is most sensitive to oil spill, not only concerning the wildlife like seabirds, fish and marine mammal, but also concerning popular areas for hunting and archeological important locations (GEUS 2011, 2012). This detailed mapping of the sensitivity of the Greenlandic coast is done out of consideration of some of the special conditions in the Greenlandic nature which will have an effect on a potential oil spill. Pollution of oil in the sea can affect greater areas and more living resources far away from the waste site, while pollution of oil on land easier can be reduced to a smaller area (Mosbech, 2002: 9). The low temperatures, the seasonal darkness, the ice and the restricted infrastructure induce that the effects of an oil spill must be expected to last longer in Greenland then in countries on a lover latitude (Mosbech, 2002: 10).

3 CONSEQUENCES OF DIFFERENT INCIDENTS

Grounding

Grounding is the most frequent reason for accidents at sea in Greenland (Søfartsstyrelsen, 2015: 4), often because of the many underwater reefs that are located all around the Greenlandic coastline. Due to the extensive coastline and comprehensive skerries, many areas along the Greenlandic coastline are not systematically, coherent and adequate measured and transferred to nautical charts. Some areas can even be considered uncharted. The problem is especially widespread on the east coast. Radar and sonar can be used, but are not in all situations sufficient e.g. with high speed or under heavy wind or stream (Søfartsstyrelsen, 2008: 9).

Danish Maritime Authorities' report on accidents from 2015 show the number of accidents in Greenlandic waters in the period from 2010 to 2014 and type of accident (Søfartsstyrelsen, 2015; 5). As mentioned, grounding is the most frequent type of accidents.

TABLE 28 NUMBER OF ACCIDENTS IN GREENLANDIC WATERS DIVIDED BY TYPE OF ACCIDENT

	2010	2011	2012	2013	2014
Collision or contact damage	3	1	0	0	0
Damage on ship or equipment	0	0	1	0	0
Fire/explosion	0	0	0	1	1
Water ingress incl. sink	0	0	1	0	0
Grounding	3	4	6	1	3
Control failure	0	1	0	0	0

It is noted in the Danish Maritime Authorities' report that presumably not all sea accidents in Greenlandic waters are reported (Søfartsstyrelsen, 2015: 5).

In 2006 one of The Danish Maritime Authorities' own ships, doing measurement for nautical charts, first grounded and later sank in the Arsuk fjord in the southern Greenland. This ship was provided with equipment to locate underwater reefs, and it is therefore very indicative when a ship like this, ground and sink. Before the attempt to salvage the grounded vessel, the vessel had been drain from oil, so no pollution was done (Danish Naval History). To navigate in Greenlandic waters is apparently challenging even with a lot of equipment.

Due to the many underwater skerries along the Greenlandic coast grounding is occurring for all type of ships. The risk of human lives is estimated to be moderate. It is possible that sharp reefs can cut up the hull of the vessel and water can ingress, but the vessel is on firm ground and huge water ingress is necessary if the vessel should overturn and downright sink. Also sailing in the difficult Greenlandic waters is most often done with the use of either local or qualified navigators that have experience with sailing in arctic waters (Søfartsstyrelsen, 2006; 27) and most often recommended routes are followed by vessels, as recommended routes are acknowledged among navigators as being reliable area to navigate (Søfartsstyrelsen, 2008; 3). Using qualified navigators and following recommended routes is though not always enough to avoid grounding in the difficult Greenlandic waters. Both in 2010 and 2012 the passenger vessel Sarfaq Ittuk that sails along the west coast grounded - in 2010 close to Napasoq south of Maniitsoq and in 2012 in the harbour of Qaqortoq. Thus, not even for vessels that often navigate in these waters and with an experienced crew is it possible to avoid the difficult skerries.

The risk of grounding is also due to that the reef can cut up the hull of the vessel and oil or diesel can leak. This risk is greatest in the case of vessels carrying a large amount of oil or diesel, that is tankers, cargo vessels, intercontinental traffic, cruise and passenger vessels. If one of these types of vessels is grounding the risk for the environment is larger than e.g. smaller motor boats and fishing vessels. The risk is also higher for cruise ships and passenger traffic, as these vessels are sailing close to shore for the satisfaction of their cruise guests and passengers, compared to intercontinental traffic and cargo vessels which are sailing far from the shore.

Collision

From table 26 it is seen that collision or contact damage is occurring rather rare. Collision in Greenlandic waters can either be collision with ice or collision with another vessel; this is though less probable because of the relatively low ship activity and traffic in Greenland due to the small population, small export/import and absence of international transit routes. Collision was none the less the theme of a tactical exercise between the different actors in the Greenlandic emergency organisation in 2014, when the scenario was a collision between a cargo vessel and a cruise ship (Forsvaret, u.å. a).

A collision with ice is a more frequent risk in the Greenlandic waters. Ice formations occur in all water around Greenland during winter, and sea ice is present all year round in varying quantity. The prevalence of drifting ice depends on the season, but can within same month change a great deal from one year to another, which makes it almost impossible to predict the ice situation. The large drop in temperature due to an area with a lot of ice is often causing fog, which makes it even more difficult to navigate in icy waters (Søfartsstyrelsen, 2008: 10). At last the massive icebergs coming from the northeast area and moving along the east coast, are in constant movement and can in no time block very big areas and close up fjord outlets (Søfartsstyrelsen, 2008: 27).

In 2012 the containership Vega Sagittarius grounded shortly after taking off from Nuuk. The accident happened in trying to avoid collision with ice but the change of direction led to the grounding on an underwater reef. The following report on the accident concluded that error in human decision-making caused the accident. Furthermore, the report criticised that profound precaution due to navigation in Greenlandic waters was not followed (Danish Maritime Accident Investigation Board, 2013). The example with Vega Sagittarius exemplifies under what difficult conditions ships is manoeuvring when sailing in Greenland.

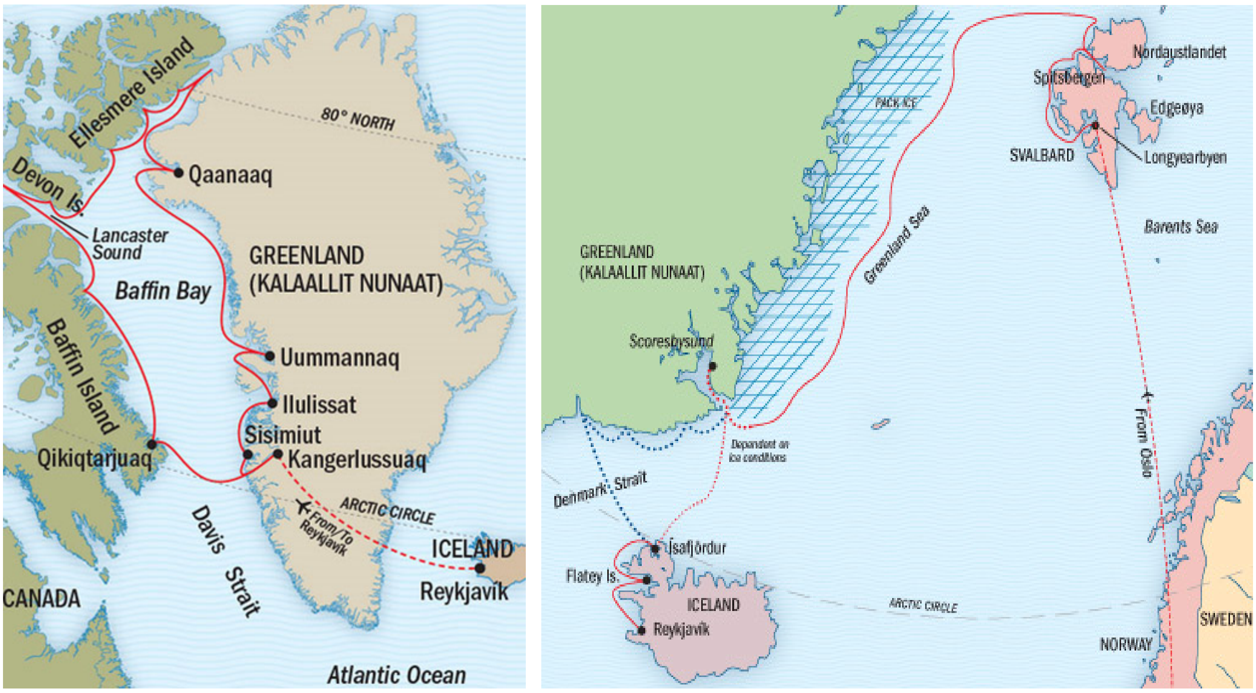
The level of risk of collision in Greenlandic waters is rather low, which must result from great caution and the noticing of advices from e.g. The Danish Meteorological Institute ice charts. The consequences of collision and the risk of human lives are estimated to a minimum because most vessels use navigators that have great experience in sailing arctic waters, so called ice navigators that are qualified to navigate in icy waters. Use of a local and qualified navigator allow for better safety. This is emphasised by Greenlandic navigators reporting on the missing knowledge about navigating in icy waters among foreign captains. It is hard for inexperienced captains to understand all the risk connected to navigating in icy waters (Søfartsstyrelsen, 2006; 27).

Environmental risk assessment and consequences are estimated to less when considering fishing vessels and smaller boats. First these vessels are often sailed with local knowledge and experience, and these vessels carry a smaller amount of oil or diesel so the environmental damage will be less in case of an accident. Considering cargo vessels, intercontinental traffic and cruise ships the environmental risk is estimated to moderate because these types of vessels carry more oil or diesel and the spill can be that much bigger. Also these vessels are often sailed by inexperienced captains, and especially cruise ships sail close to ice bergs and glaciers to give their guest a unique experience.

POSITION AND SURROUNDINGS

CRUISE SHIPS

The position and the surroundings of an accident can have serious consequences for both human lives and the environment. Most cruise ships are present in the waters Southwest and Midwest of Greenland (Visit Greenland), but more travel companies offer cruises to some of the most remote areas in Greenland, as high north up on the east coast as waters around Svalbard, on the west coast further north than Thule Airbase and even special expedition cruises plan routes all the way around Greenland.



SOURCE: WWW.EXPEDICTIONS.COM

SOURCE: WWW.QUARKEXPEDITION.COM

FIGURE 10 MAPS SHOWING THE MORE REMOTE AND ISOLATED ROUTES THAT SOME CRUISES TAKE IN GREENLAND

Due to the much dispersed infrastructure the position of cruise ship in such remote and isolated areas constitute a serious risk to human lives if severe accidents or illness occur, because of the long distance to the nearest harbour, heliport or medical service. Also in case of an accident, the arctic climate and nature in these remote areas, in form of low temperatures and cold water, fast changing and sometimes very heavy weather create risk of human lives in situations where it is necessary to remove the passengers. According to the Danish Maritime Authorities cruise traffic in very remote and isolated areas is a result of travel companies offering the unique cruise, which is the reason why the cruises often take place on the east coast and also in the fjords (Søfartsstyrelsen, 2008; 21).

SAREX AND ARCTIC RESPONSE:

An accident involving a cruise ship in one of these very remote areas has never occurred but the Greenlandic SAR preparedness has had training exercises that dealt with exactly such a scenario. In the fall of 2012 and 2013 two SAR exercises has been conducted by the Kingdom of Denmark in the Greenlandic waters with people involved from many different organisations in the Arctic states. Both years the scenario was centered on a cruise ship in distress on the northeast coast of Greenland necessitating a large and complex SAR operation. The two exercises were very realistic in case of meteorological, geography, borders, infrastructure, political and economic conditions etc. The only thing not realistic was that all capacities had to be pre-positioned prior to the exercise. From the SAR exercises in 2012 to 2013 the SAREX exercise was extended to include also maritime pollution (SAREX Greenland Sea, 2013: 6-7). Gaining experience in cooperation among the stakeholders was a key priority, and for this reason alone, the exercise can be described as a success (SAREX Greenland Sea, 2012: 6, SAREX Greenland Sea, 2013: 6).

The evaluations in general emphasise the participating organisations were able to coordinate in a remote area and overcome initial communication problems. That said, the evaluation also points to inadequate means of communication, especially long-range communications from the remote incident to the Rescue Coordination Centre and higher authorities, insufficient information both horizontally and vertically, absence of a common situation picture, a need for more robust command and control at the operational and cross-organisational, as opposed to the tactical, level and a need for a shared system or registry of available SAR resources (SAREX Greenland Sea, 2012; 6), the need for an Air Task Organisation for handling a large number of aircrafts, a formal SAR cooperation agreement between the national coordination forums at the strategic level in Denmark/Greenland and Iceland, and a plan for maritime pollution equipment (SAREX Greenland Sea 2013: 6). Most of the criticism in the evaluation can be met through more of these training exercises. Some of the critics point to the need of a more constant coordination and the formation of new cooperation organisations. The biggest challenge is to improve the technical communication problems in the remote arctic area.

Due to more activity in the Arctic region the present defence agreement have among other things established the Arctic Emergency Force (*Arktisk Beredskabsstyrke*) which in September 2015 held a military defence exercise in Greenland where some of the tasks were SAR and damning of maritime pollution (Forsvaret for Danmark, u.å. b). The evaluation of Arctic Response exercise has not yet been published but both communication equipment and satellite monitoring has been requested based on this military exercise.

The risk of human lives in case of a cruise ship in distress is estimated to theoretically possible. Since cruise ships area sailing in remote and isolated areas, the consequences of such an accident is estimated to serious due to the dispersed infrastructure and the intense arctic climate and nature.

The risk for the environment is also estimated to serious, due to two reasons. First the remote position is causing a risk in case of an oil spill, because it will take long time for GOSR to arrive at the waste site, and the oil spill can dissipate in the meantime. Second it is expected that cruise ships are sailing to these remote areas to experience a lot of ice, the presence of the ice can complicate the effort to prevent the oil in dissipating, and so can heavy weather.

Other maritime traffic

Cargo vessels is most often sailing on the west coast and in between towns, which are in reach from the harbours, heliports, medical service and the pollution response available on the west coast. Even though the distance between the towns and settlements can be far from the nearest harbour or heliport, these ships often use qualified navigators (Søfartsstyrelsen, 2008; 27) and follow recommended routes (Søfartsstyrelsen, 2006: 3). The risk for human lives and the environment is therefore estimated to moderate.

As described above in table 3 it is most often the smaller boats that are in need of help or SAR operations. The dinghies and small motor boats is most likely used for fishing and owned by self-employed fishermen or hunters. Because of an estimated smaller economy in these ownerships, the condition of these dinghies and small motor boats is questionable. A technical risk is present if the boats are old and worn out, which also creates a risk to the lives of the fishermen or hunters. That said, these small fishing vessels are often manoeuvred by the most experienced navigators that also know the localities very well, and the vessels are operating within reach from the coast. Accidents for vessels used for fishing is occurring more often than cargo vessels, but still the consequences are estimated to be moderate. The risk of the environment is also estimated to moderate since the fishing vessels are most often in operation on the west coast closer to the pollution response and they are often carrying only a small amount of oil or diesel.

Violence and terror

Incidents of violence means violent behaviour towards persons or/and physical installations. The development of oil and gas activity in Greenland may increase the presence of environmental activism. Greenpeace is present in Greenland both to preserve the environment and Arctic wildlife. Latest Greenpeace sailed in the Greenlandic waters was in August 2015 to draw attention to the seismic sound wave measurement for oil explorations taking place in northeast Greenland. Greenpeace criticises the measurement for being a threat to the area's marine mammals. In 2011 Greenpeace performed an action against offshore installation performing test drillings for oil west of the Disco Island. Later Greenpeace Denmark and Greenpeace International has been sentenced to pay a large fine due to their three occupations of the offshore installation, where one of the actions composed a risk with regard to safety.

Greenpeace is present in Greenlandic waters and does from time to time perform actions, but since it is a principle of Greenpeace actions not to do violent but direct action, the risk of human lives is estimated as insignificant to all types of vessels. Also since Greenpeace foundation is to protect the environment, the risk to the environment is estimated as insignificant for all types of vessels.

4 RISK ASSESSMENT

TABLE 29 POSSIBLE VARIATIONS OF ACCIDENTS DEPENDING ON TYPES OF VESSELS AND EVENTS

	Tourist/cruise ship	Cargo/tanker/tug/intercontinental transport/passenger transport/petroleum activities/research	Fisheries
Grounding	T-G	C-G	F-G
Collision	T-C	C-C	F-C
Position/surroundings	T-P	C-P	F-P
Violence/terror	T-V	C-V	F-V

Grounding is the accident most often occurring in Greenlandic waters due to the many underwater reefs and skerries. Still the risk of human lives are estimated to moderate for all types of vessels due to the often use of navigators with local knowledge and following the recommended routes. The risk of the environment due to grounding is estimated to moderate for tourist/cruise ships and for cargo vessels, tankers, tugs, international transport, passenger transport, petroleum activities and research vessels due to the larger amount of oil or diesels these types are carrying compared to fishing vessels and smaller motor boats.

The collision with ice or other vessels is occurring rather rare and the risks of human lives are estimated to minor due to the often use of navigators with great experience when sailing in icy waters. The estimated level of environmental risk for fishing vessels or smaller motor boats is lower since these types of vessels are carrying less oil or diesel compared to larger types of vessels. The environmental risk for tourist/cruise ships and for cargo vessels, tankers, tugs, international transport, passenger transport, petroleum activities and research vessels is estimated to moderate due to the larger amount of oil or diesel, and also some of these ships are sailed by inexperienced crew, and especially cruise ships sail close to the ice.

The position and the surroundings for a potential accident can be significant, not least for the tourist and cruise ships that sail in remote and isolated areas. The risk of human lives and the environment for tourist and cruise ships is estimated to significant even though no such accidents has happened in Greenlandic waters. The significant risk is due to the dispersed infrastructure that complicates both a SAR operation and environmental control, also the surroundings in form of the unpredictable and unstable arctic nature is complicating both SAR operations and environmental control. Considering cargo vessels, tankers, tugs, international transport, passenger transport, petroleum activities and research vessels the risk of an accident in a position far from the nearest harbour, heliport, medical service or environmental response is estimated to occurring very rare and the consequences to be moderate due to the often use of qualified and Greenlandic navigators. Accidents are occurring more often to fishing vessels and smaller motor boats but because the experienced fishermen with local knowledge, and because the vessel are operating within reach from the coast, the risk of human lives is estimated to only moderate. The risk of the environment is also estimated to moderate due to the smaller amount of oil and diesel fishing vessels and smaller motor boats are carrying.

Due to the low level of activism in Greenland against maritime activities like e.g. search for oil the risk of violence and/or terror to human lives and to the environment is estimated to insignificant.

TABLE 30 RISK MATRIX OF CONSEQUENCES FOR HUMAN LIVES

	Insignificant	Minor	Moderate	Significant	Serious
5 – Frequently					
4 – Relatively frequently					
3 – Occurs			T-G, C-G, F-G, F-P		
2 – Very rare	T-V, C-V, F-V	T-C, C-C, F-C	C-P		
1 – Theoretically possible					T-P
	Insignificant	Minor	Moderate	Significant	Serious

TABLE 31 RISK MATRIX OF CONSEQUENCES FOR THE ENVIRONMENT

	Insignificant	Minor	Moderate	Significant	Serious
5 – Frequently					
4 – Relatively frequently					
3 – Occurs		F-G	T-G ,C-G, F-P		
2 – Very rare	T-V, C-V, F-V	F-C	T-C, C-C, C-P		
1 – Theoretically possible					T-P
	Insignificant	Minor	Moderate	Significant	Serious

SUMMARY

As it is shown in the sections above, the types of vessels most often in distress and in need of SAR operations are dinghies, smaller motor boats and fishing vessels. These types of vessels are not creating the largest risk for either human lives or the environment, since these type of vessels are not transporting a lot of passengers or carrying a lot of diesel or oil. The Greenlandic emergency prevention, preparedness and response needs however also to be able to handle larger emergency situations. Since 2009 the number of cruises in Greenlandic waters has risen 14 percent and there is an expectation of more maritime traffic and activity in the Greenlandic waters due to the effect of climate change with longer sailing seasons and wider sailing possibilities. The Greenlandic emergency response needs therefore the resources and capacity to handle smaller SAR operations to e.g. smaller vessels but larger operations will not only require the Greenlandic SAR preparedness and OSR resources and capacity but also assistance from Denmark and probably Canada or Iceland, as well, depending on the position and the size of a potential accident.

The largest challenge for the current SAR service and pollution response in Greenland is the enormous sea and land area that is within Greenland's responsibility area and those challenges given by the natural conditions present in this part of the Arctic including the relative dispersed infrastructure which does not render a fast and efficient emergency response in all areas of Greenland. The worst possible accident is a large cruise ship in distress in a remote and isolated area on the north or northeast coast of Greenland with many thousand passengers and a large amount of diesel or oil onboard. The solution to such a risk is a costly expansion of the infrastructure in these remote and isolated areas or improved measurement of popular destinations, which is also associated with large expenditures (Søfartsstyrelsen, 2008; 21) or a change of the organization and division of responsibilities concerning SAR and OSR resources and capacities.

CONCLUSION: MARITIME ACTIVITY RISK PATTERNS IN THE HIGH NORTH
BY NATALIA ANDREASSEN AND ODD JARL BORCH

This report analyzes current commercial and governmental activity in sea regions north of the Polar Circle from the Kara Sea to the Baffin Bay. It includes an overview of dominating risk factors, types and probability of unwanted incidents and consequences of different incidents. The report takes into account the estimated increase in some types of maritime activity in the High North and analyses major accidents that may have implications on the risk assessments. The report also provides risk assessments across the studied territories of the Arctic countries Russia, Norway, Greenland and Iceland.

For all countries, the main risk factors include severe and unpredictable climatic conditions, expansion of operational range for many categories of vessels into areas with limited or no infrastructure, distance to emergency preparedness resources, technical limitations as to both vessel and equipment in cold climate areas, and human factors like lack in experience, navigational competence and crew fatigue. In Russia, human factors prevail as the main reason for most accidents. Norway especially highlights seasonal changes especially during winter months and poorly charted waters especially in the areas remote from the mainland. Iceland has listed the same risk factors, and mentioned that the combination of budgetary restraints and international shipping development may challenge the Icelandic preparedness system. In Greenland, there is an enormous sea and coastal area of emergency preparedness responsibility and dispersed infrastructure. The main risk factor there is challenging underwater skerries, which make navigation difficult even for well-equipped vessels and experienced crew, and the capacities for self-support of the vessels for a longer time in case of accidents.

The increased physical accessibility of the earlier ice-covered Arctic waters may increase the number of unwanted incidents because of lack of navigational support and limited experience. Throughout the report, the examples of the most relevant accidents are given. The table in the appendix illuminates both the range of risk areas and the consequences.

These examples show that consequences of different types of accidents in the High North sea regions may be severe. Grounding is the most frequent type of accident by statistics and by activity estimates in all countries. In other regions, grounding may not represent a severe incident. In the High North, both the unprotected coastlines and the time until towing and SAR-capacities are able to arrive may increase the negative consequences. The probability of collisions between vessels and with ice is rather low according to statistics. Modern weather and ice forecasting and advanced navigation instruments contribute to a reduction of probability. However, major events demonstrate that in some polar waters it may be challenging. Given the estimated growth of international transit shipping especially to and from Russian oil and gas fields, the risk of collision in icy areas may increase.

Statistics illuminate that fire on board has a quite high probability, and at the same time consequences in heavy weather and far from the nearest harbor can be very dramatic. Own firefighting capacity on board of vessels and installation is crucial in reducing the consequences in this field.

Statistics of terror and violent actions in the sea areas of the High North has a very low probability rate and hardly assessable consequences due to the costs of planning and performing such an act without being discovered. However, the examples in the enclosed table shows that especially environmental activism and possible destruction action may occur, also with the risk of lives lost.

As for types of vessels, the fishing fleet represents the highest probability of accidents due to their all-year operation in all studied sea areas. The fishing fleet also varies as to technical quality and size. Many vessels are also stretching their limits as to weather and wave conditions and distances to the nearest harbor.

Dry cargo vessels following routs close to shore have a history of high risk of stranding with dramatic consequences as to both life and environment. Along the Norwegian mainland coastline, the frequency of grounding and fire among fishing vessels is high. Smaller motor boats and fishing vessels in the Greenland region are most often in distress, but they are not creating the largest risk either to human lives or for the environment, since these are small vessels. In Russian Arctic the risks of fire and collision among fishing vessels are assessed as rather high as well. The statistics shows high frequency and low consequences. However, dramatic examples with larger fishing trawlers demonstrate the challenges of SAR operations in remote Arctic waters.

The increased cruise traffic in all countries represents a new challenge as they search for exposed areas with larger vessels, including many elderly passengers. The probability of accidents is low. The Polar code will increase safety and preparedness in the cruise fleet. The industry is also taking measures to reduce the risks. However, the consequences of a major accident may be dramatic, especially related to grounding and fire on board. Evacuation at sea is very problematic due to limited adaptation of rescue equipment to the cold climate. In Norway, oil spills and life-threatening accidents with large cruise ships are the most discussed events due to the consequences and the preparedness capacity for mass rescue operations, hospital care and oil spill response to heavy oil leakages. In Greenlandic sea areas significant risk for human lives and the environment is also estimated for tourist and cruise ships that sail in remote and isolated areas. Russia also estimates that the risks for people are highest in case of fire or other incidents on tourist ships.

An increased amount of shuttle oil tankers especially in the Russian Arctic represents a certain risk due to the limited possibility of oil recovery capacities in the remote areas. Increased cooperation between the coastal authorities on sea traffic surveillance and introduction of vessel traffic systems with fixed fairways for vessels carrying dangerous goods reduce the probability of accidents. However, the oil recovery equipment and techniques available are not well adapted to cold and icy waters, and large amounts of heavy oil represent a significant challenge.

In Iceland, new patterns of vessel traffic represent new challenges, particularly with respect to controlling pollution prevention and salvage operations. Government institutions may lack the power to take all measures considered necessary for life saving equipment investments, sailing routes and efforts to prevent marine pollution and assure refund of salvage operations. There is a continuous need for evaluation of government emergency capacity as the regional pattern of vessel operation changes, and this has to be an on-going process.

The risk factors for maritime activity remain the same. Nevertheless, better vessels, safety equipment adapted to cold climate, improved technology, improved contingency planning, routines and rescue procedures, and safety and rescue skills training may contribute to better preparedness system. An effective cooperation between the shipping companies and the government institutions, and between emergency preparedness centers continuously assessing risks and consequences are in demand.

APPENDIX OVERVIEW OF THE EXAMPLES IN THE REPORT BY INCIDENT TYPE, RISK FACTOR AND REASON AND CONSEQUENCES

Land, place and date of the incident	Name of the vessel, type of vessel, size	Incident type	Context	Consequences
Russia, North of Kanin Nos Peninsula, 23.07.2010	"Varnek", self-propelled pontoon with container cargo 130t	Sinking	Severe weather: Storm,	9 people died. Loss of vessel
Russia, Sea of Okhotsk, 01.04.2015	"Far East", refrigerator fishing trawler, crew 132p	Overloaded net and capsizing	Low temperatures, icing, strong winds, rough sea, darkness	69 people died. Loss of vessel
Russia, off the coast of Sakhalin island, 18.12.2011	"Kolskaya", jack-up rig with crew 67p	Rig capsized while being towed	Stability loss due to icing and rough weather, -17 degrees, water temperature 1 degree Celsius	53 people died
Russia, Usinsk, 12.08.1994	The "Usinsk" pipeline	Pipeline leak	ruptured pipeline, ice floes	huge oil spill (ca. 102,000 barrels)
Russia, Sakhalin shelf, 2009	"Molikpak" platform, 90000 barrels per day.	System failure	ice near the rig	165 l oil spill

Russia, Prirazlomnaya offshore platform, 18.09.2013	“Prirazlomnaya” offshore platform, activists sailed from the “Arctic Sunrise” using inflatable boats	Environment activism Greenpeace	Arctic waters	Commercial losses
Russia, Barents Sea, off the coast Rybachiy, Peninsula, 18.12.2007	“Viktor Koryakin”, dry cargo vessel, with crew 12p and timber cargo	Grounding/Anchored by the coast	gale force winds, no helicopters available, the nearest – Sea king from Banak (Norway)	All rescued, no large oil spill
Russia, Long Strait, 09.10.1983	"Nina Sagaydak", MV, in caravan with icebreakers "Kamensk-Uralskiy" and "Urengoy"	Collision/ jammed by big, old drift-ice, three vessels collision	compressed ice between ships in the caravan	All evacuated, ship sank
Russia, Kara Sea, september 2013	“Nordvik”, tanker 138m long	Collision	Ice floe, sailed without icebreaker assistance	Loss of values
Russia, route from Dudinka to Murmansk, 15.12.2011	“Vaigach”, nuclear icebreaker	Fire	Several explosions	Loss of values
Russia, shipyard in Arkhangelsk, February 2010	"Alushta", passenger tourist vessel, with 30 workers on borad	Fire on board	Hard frost outside, high combustion temperature	4 delivered to hospital with burn injuries and toxic poisoning, the ship burned out

Russia, Laptev sea, 27.08.2010	"Alexey Kulakovsky", tug boat with 14 crew	Sinking	Sea waves 2,5 meters, western wind of 20 meters per second, technical failure and unseaworthy conditions	11 people died
Russia, Pechora Sea, towards Murmansk, 07.11.2014	“Saturn”, jack-up rig	Damaged in storm while being towed	Storm, helipad damaged, handled by three professional tugboats from Norway	Loss of values
Russia, White Sea, 08.06.2014	“Barents-1100” fast boat	Surprised by weather and ran out of fuel	Severe storm	Crew and boat was saved by nuclear submarine “Voronezh”
Italy, the Mediterranean Sea, Tuscany, 13.01.212	“Costa Concordia”, cruise ship, 4,252 people onboard	Grounding / hitting the rock/ sinking	irrational navigation, bad weather, poor safety culture onboard	33 people died, loss of vessel
Norway, Lofoten archipelago, November 2014	“Marco Polo”, cruise liner M/V, 763 passengers	Grounding	Got stuck on sand bank	No vessel damage Delays Loss of values
USA, the Gulf of Mexico, April 2010	Macondo well, “Deepwater Horizon oil spill”, 126 crew members	Fire/Explosion, oil spill	Large accident, offshore deepwater, technical failure	11 people died., Extensive damage to marine and wildlife habitats and fishing and tourism. Loss of rig
Alaska, March 1989	“Exxon Valdez” disaster, oil tanker	Grounding/ struck a reef	sub-Arctic vulnerable waters	42,000 m3 of crude oil, polluted shoreline

Norway, Svalbard area, 1989	"Maxim Gorkiy", cruise ship	Collisions with ice floes	Remoteness, night, waves	No lives lost. Severe damage to vessel
Norway, Svalbard area, July 1997	"Hanseatic", cruise ship, 26 passengers	Grounding	Good weather	No damage
Norway, outside Langesund, Telemark, 2009	"Full City", with 1100 tons of heavy fuel and diesel	Grounding	Bad weather, gale-force wind, 4-6 meters waves	Oil spill of 200 tons, appx. 2500 sea birds lost their lives
Norway, outside Ålesund, 2011	"Nordlys", coastal steamer MV, 262 people onboard	Explosion in engine room	Good weather, close to town and rescue capacity	2 people died. Severe vessel damage
Iceland, east, 06.09.2014	"Samskip Akrafell", cargo	Grounding	Navigation officer had fallen asleep, only 1patrol vessel available, lack of manpower	Crew saved, vessel damaged
Iceland, south of the Westman Islands, 30.10.2013	"Fernanda", MV, RoRo ship, crew of 11	Fire	room	Crew saved
Iceland, south coast, 1997	"Vikartindur", MV, container ship	Grounding	Engine failure, captain refused to receive assistance	death of an Icelandic Coast Guard's rescue man, sea pollution prevented, polluted coastline
Iceland, 19.12.2006	"Wilson Muuga", bulk carrier	Grounding	harsh weather conditions	death of a rescue man from a nearby Danish patrol vessel, oil leak in ocean

Iceland, port of Reykjavik, 1986	two whaling ships	Violent action	Members of the Sea Shepherd environmental organization sank the ships, protest reasons against whaling	No human injuries, two ships sank
Iceland, 500 nm southwest, September 2014	“Reykjafoss”, general cargo container ship	Other	Long distance, took 10 hours to transport injured men	injuries
Iceland, 17.09.2014	“Green Freezer”, cargo ship, 109 meter long	Grounding / struck onto a skerry	plans to use a tugboat to refloat the vessel failed	Oil spill prevented
Greenland, the Disco Bay area, August 2014	Passenger boat	Grounding	Human factors, bad weather	4 people died
Greenland, Arsuk fjord, 2006	Ship owned by Danish maritime Authority	Grounding/ sinking	Underwater skerries, navigation challenges even though the ship was equipped to locate underwater reefs	Oil pollution prevented
Greenland, west coast, 2010 and 2012	“Sarfaq Ittuk”, passenger vessel	Grounding	Underwater skerries	No significant damage
Greenland, off Nuuk 2012	“Vega Sagittarius”, large container ship	Collision with ice	Icy waters	No significant damage
Greenland, west off the Disco island, 2011	Offshore installation	Environment activism Greenpeace-action against offshore drilling	Open sea with ice Calm weather	No significant damage

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