POAC'15
Trondheim, Norway

Proceedings of the 23rd International Conference on
Port and Ocean Engineering under Arctic Conditions
June 14-18, 2015
Trondheim, Norway

MARITIME ACTIVITY IN THE HIGH NORTH – THE RANGE OF UNWANTED INCIDENTS AND RISK PATTERNS

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ABSTRACT
Growing commercial activities in the High North increase the possibility of unwanted incidents. The vulnerability related to human safety, environment, and installations or vessels, and a challenging context, call for strengthening of the preparedness system, and cross-boundary and cross-institutional collaboration.

The commercial activity in the High North includes intra- and inter-regional transportation, the search for and exploitation of hydrocarbons and other mineral resources, the fisheries, and cruise tourism. In addition, in the High North we find government activity such as research and naval operations. Activities in the Arctic are challenged by limited infrastructure, low temperatures with ice and icing, polar lows, and a fragile nature. In this paper we look into different stressors and risk factors in the High North related to life and environment. A discussion of risk is important for decisions about operational demands and the development of an adequate preparedness system.

High North is here defined as the circumpolar Arctic, delineated by the Arctic Circle. In the paper and presentation we will focus on the Atlantic Sector of the Arctic.

The main operational risk factors faced include geographical remoteness, climate-change related aspects and weather, electronic communications challenges, sea ice, lack of precise maps or hydrographic and meteorological data. Activity and probability of accidents differs in different parts of the Arctic. An overview of maritime activity and risk assessment are given in the paper. Implications for the preparedness systems are discussed.

INTRODUCTION
Increasing human activity in the Arctic creates great concern about accidents and consequences for life and nature. There is a need for increased understanding of the risk factors, risk mitigating tools, and adequate preparedness system capacities. In this paper we analyze the expected activity level and risk patterns in the Norwegian and and West-Russian Arctic, i.e. the Barents Sea to Novaya Zemlya and the official boundary of the Northern Sea Route.

The High North is the place of stable and growing political and economic interest from several countries, including Russia and Norway. Both countries have special Arctic strategies proclaimed as important issues (Norwegian Government, 2006, Norwegian Government, 2014, Russian Federation, 2009, Russian Federation, 2013). Nevertheless, there is no strict definition of "High North". In the common sense, the High North is similar to the Arctic and includes territories to the north of Polar Circle (66o34') (Skagestad, 2010).

In our study we take into consideration the conical shape sea area to the north of 66o34' up to the North Pole and between meridians 00o00' and 58o00' and Novaya Zemlya Coast on the east (see the map at Figure 1). We divide this area into 3 regions. These 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 1).

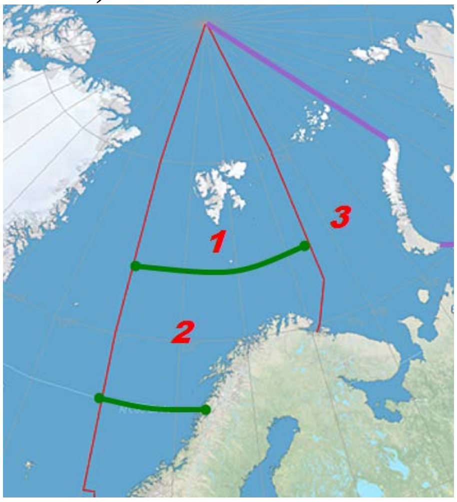


Figure 1. Three regions under consideration. Base map is "Norwegian rescue service's area of responsibility" (red lines) (BarentsWatch, 2013)

Table 1. Main features of the regions under consideration

Region	1) Svalbard area	2) Mainland Norway (up to Bear Island on the north)	3) Russian part of the Barents Sea
Boundary W-E	00°00' and 35 °00'East	00°00' and 35 °00'East	35 °00' and 58 °00'
Boundary N-S	74 °00'- 90 °00'	66 °34' and 74 °00'	Coastal line - 90 °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	Polar night/day. Polar low. Fading North-Atlantic current and influence of Arctic. Sea ice influx from Kara Sea and the Arctic Ocean
Economic features	Population ca. 2800 Very small economic activity	Population: ca 500 000 Rather equal activities along the region. Oil and gas exploration	Population: ca. 700 000 All activities concentrate in the south part. Oil/gas exploration
Political features	Norwegian jurisdiction Unmilitary zone Russian fishing and coal mining activities.	Norwegian jurisdiction	Russian jurisdiction
Characteristics navigational difficulties	Sea ice on the North Reduced satellite coverage. Lack of maps.	Storms, Icing, "Heavy traffic" on most common ship routes and ports	Storms, Icing Sea ice in South-East and North
Maritime activity	Fishery, Tourism, Cargo, Science, Tankers	Cargo, Tankers, Fishery, Tourism, Science	Cargo, Tankers, Fishery, Science ,Tourism,
Shipping seasonal variation	Large seasonal variation with peak in summer	Quite stable during the year	Seasonal increase due to Northern Sea Route activity in summer
SAR features	Svalbard Governor with help of Red Cross. Extremely low human resources	North Norway JRCC in Bodø Good equipped with both tools and human resources	Russian Rescue centers in Murmansk, Arkhangelsk and Naryan-Mar Performing rescue operations in heavy ice conditions is possible

DOMINATING RISK FACTORS / STRESSORS

Historically, the industrial exploitation of the High North has developed faster than the development of necessary infrastructure. One challenge is the preparedness systems for both search and rescue and oil spill recovery. It is important to have a profound knowledge about the dominating risk factors or stressors. Below we illuminate the difference in the regions as to risk factors.

1) Svalbard area

High Arctic conditions that may impact the probability of incidents are poorly charted waters and remoteness, in addition to 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 economic 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 person accidents and missing people due to sinking ships. Fire and wrecking are just as possible as in other places. However, the limited capacities for mitigating the consequences of accidents means 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 the case of possible industrial development, the business players and authorities are likely to face more public scrutiny than those in the past and in other places.

2) Mainland Norway

The resources along the coast of mainland Norway create many business opportunities, and at the same time can have an impact on the likelihood of accidents. Along the coast there are large resources related to the fisheries, fish farming, oil and gas resources, and attractive regions for tourists and the local population. This generates large intra-regional traffic. In addition, there is quite a large inter-regional transport activity.

There are more stress factors, such as growing global demand, shifting market conditions, increased physical access, environmental conflicts, and changing geopolitics (Stepien et al., 2014). They can be referred to as political risk factors, which may influence the situation along the coast even in the stable region of Norway.

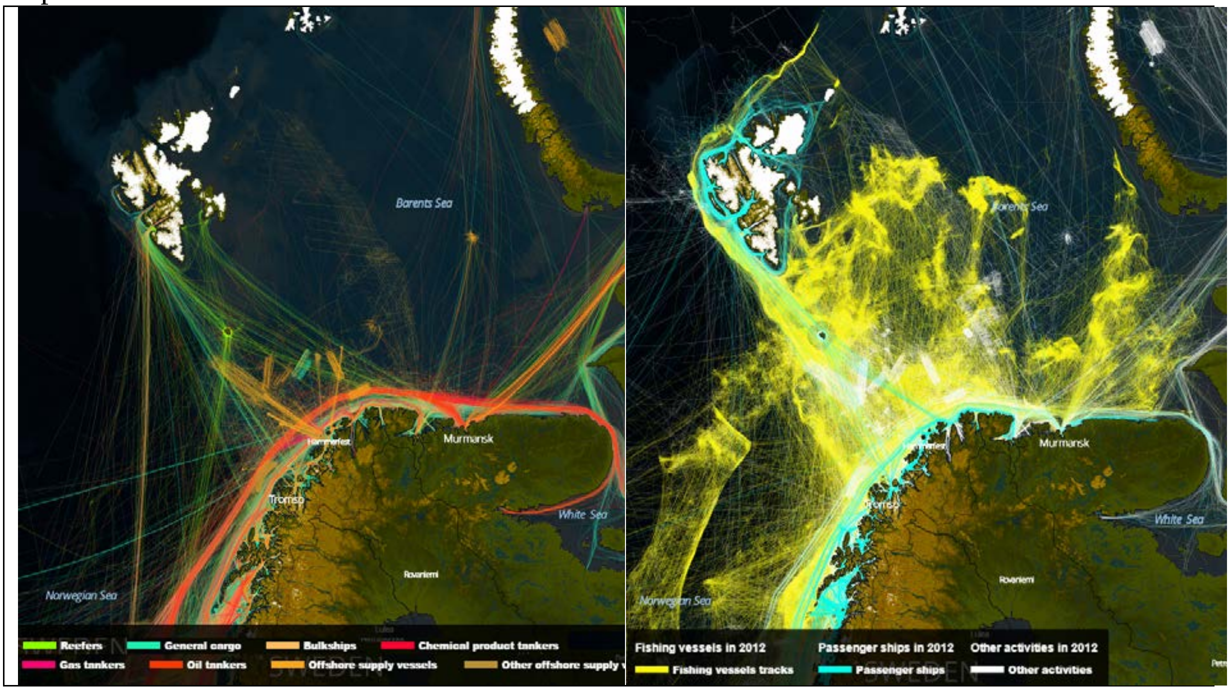
Coastal Norway is, especially in the winter, facing some of the same challenges as the Svalbard region. Stormy weather, polar lows, and snow may severely challenge the safety of the traffic along the coast, and hamper the operations of the preparedness system.

3) Russian part of the Barents Sea

All the above mentioned risk factors are relevant for the Russian Atlantic sector from the Barents Sea to the Kara Sea. There is increased traffic through the Northern Sea Route, and emerging cruise ship traffic in the Russian part of the Barents Sea. There is also increased Russian activity in offshore oil and gas exploration as the industry moves offshore towards the shelf. Thus arises the concern for search and rescue capacities, and for security issues. Going east, the distances to 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. The ice challenges in this region are quite high, and the icebreaker fleet becomes important for safety here. Russian icebreakers assist cargo and passenger vessels and military ships when crossing the ice on the Northern Sea Route, and provide safe Arctic tourism. Limited infrastructure in this region makes it difficult to face accidents with the necessary resources, also included within the preparedness system.

ACTIVITY AND PROBABILITY OF INCIDENTS

The activity of vessels and installations varies between sea areas and over the year. The pattern of ship traffic is presented in Figures 2-3 for the High North territory and for different types of ships.



Figures 2 and 3. Ship traffic in 2012 for 2A) cargo (refrigerator – green; general – blue), tankers (red) and supply vessels (orange); 2B) fishing (yellow), passenger (bright blue) ship and the others (white).

1) Svalbard area

There are 4 main groups of vessels in the Svalbard area. These are tourist, cargo, research and fishing vessels. Naturally, the cruise ships dominate as to 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. An 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. 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 DNV GL, presented in 2 reports (DNV GL, 2014c, DNV GL, 2014a), 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 six years on average, according to two studies by a foundation analyzing future traffic patterns. 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.

2) Mainland Norway

The coastal sea traffic includes passenger and cargo transport along the coast of mainland Norway, and from neighboring countries, with use of smaller and medium-sized vessels. The coastal steamer, with up to 1,100 people on board, represents one of the largest and most frequent actors of passenger transport. The volume of internal transport in coastal regions is relatively stable. 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).

A significant increase in traffic is in the shipping of goods between supply bases and installations on land and floating offshore platforms, initially from Sandnessjøen and Hammerfest, first from the Goliat field, and in the future from the planned 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 132 risk vessels per month on average for the region (www.kystverket.no).

Intercontinental transport is primarily related to the Northern Sea Route (Northeast Passage) between Europe and Asia. The activity of the fishing fleet takes place close to shore and in open waters almost all year long. Further from 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 Fishing Ministry database, there are 3426 fishing vessels registered in Northern Norway (www.fiskeridir.no).

Petroleum activity is primarily related to exploration, development and production in coastal areas of the Norwegian Sea and the southern Barents Sea. The activity of exploration is rapidly increasing in these areas and moving further north and further east and west. The 23rd Norwegian oil and gas license round opens large areas in the Barents Sea for exploration.

There is also growing research and observation activity in the High North, which includes various research vessels of many jurisdictions. Maritime tourism is linked to small and large passenger vessels. There is a strong increase in both the number of ships and passengers along the coast of Norway. This includes large ships with several thousand persons onboard. 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.

Norwegian Maritime Authority controls incidents statistics. Table 2 demonstrates 558 accidents registered in their database for the region between mainland Norway and Svalbard.

Table 2. Percentage of traffic and accidents

	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 %

Most of the accidents happen along the Norwegian coast. The register 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 (www.sjofartsdir.no).

3) Russian part of Barents Sea

The categories of ships are mostly the same as used in sectors 1 and 2. However, a larger number of vessels are ice strengthened or icebreakers. The activities concentrated in the South-western part of Arctic Russia are similar to mainland Norway. Arctic cruises are few, however, but increasing into the harbors of Murmansk and Arkhangelsk. Ferries and combined transport-passenger vessels deliver supplies to the populations in the coastal settlements of deliver personnel on the drilling platform Prirazlomnaya and other Arctic sites.

The statistics for transportation in this region show that the freight turnover of Russian Arctic ports decreased in 2014 by 24.2% compared to the year 2013 and amounted to 35 million tons (Association of sea commercial ports of Russia, 2015). The decrease in transshipment of liquid bulk cargo ports of the basin amounted to 54.7% to 9.8 million tons (Murmansk - 87.7%, Arkhangelsk - 12.5%) to 2.4 million tons. Transshipment of dry cargo ports increased on 2.5% and amounted to 25.2 million tons (Murmansk - 0.4 %, Arkhangelsk - 5.6%). But in general, there was a decrease in transshipment: in Murmansk - by 30.4% to 21.9 million tons, Arkhangelsk - 5.4% to 4.2 million tons. The growth in cargo handling in the port of Varandey was 9.3% to 5.9 million tons.

The decrease in foreign trade is most likely temporary, established under the influence of the global recession, as well as economic and technical sanctions introduced by western countries in 2014. The Russian oil and gas companies Gazprom and Rosneft implemented the project for exploration drilling in the Pechora sea shelf and Novaya Zemlya that significantly impacted on marine activities (Association of sea commercial ports of Russia, 2015). It is uncertain whether this activity will continue in the next year.

Over the last 10 years, the transport of cabotage cargoes increased from 23% to 31%. There was a reorientation of a considerable part of the cargo from large-tonnage vessels of unlimited sailing to smaller ships of river-sea navigation and coastal vessels. These changes are alarming, because 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.

Navigation via the Northern Sea Route, which is officially located to the east of Novaya Zemlya, is very important for the region. There was rapid increase of usage of this route in the previous four years. In 2013, 71 ships carried 1,355,897 tons of cargo through the Northern Sea Route (NSR information office, 2015), but a dramatic downturn occurred in 2014. The amount of cargo transported in transit dropped 77 percent compared to 2013. In the petroleum sector, there has been a growing amount of offshore exploration activity. As an example, an expedition in the Kara Sea included 10-15 vessels with several hundred crew. The logistics in this area is complicated, hampered by the lack of harbors and other infrastructure.

CONSEQUENCES OF DIFFERENT ACCIDENTS

The severity of accidents greatly depends on place and time and the preparedness to response, rescue and eliminate the negative impact. This may vary between the regions:

1) 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 much local experience to learn from. The most relevant previous oil spill for making comparisons 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 few tankers operating in Svalbard area now, so this type of accident 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 and special plan has been developed for Svalbard (Sysselmannen på Svalbard, 2010).
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 finished without any big injuries or human losses. They showed, however, 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.

2) Mainland Norway
Due to heavy traffic, the probability for accidents is high in the region of coastal Norway, even though measures by the coastal authority as vessel traffic zones and certificate demands reduce the probability of severe accidents. The cold climate in the winter increases the risk to life after an accident. Vessels operating all year have the highest risk. This includes the fishing fleet, but also large passenger ships operating for the larger part of the year.
One of the most serious negative effects on the local ecosystems may be marine heavy oil spills. As an example, the cruise ship M/V Marco Polo grounded in the center of the Lofoten islands in November 2014 with 800m3 fuel oil on board. Luckily, no pollution occurred. If this had happened it may have had severe consequences in an area with a very sensitive nature and a large amount of tourist attractions.
Oil and gas activity also represents some risk even though the number of accidents has been very few. Assessments of the risk of a worst case scenario, such as as a serious blow out in the Lofoten region during the most critical exploration period, shows that there is a risk of a serious blow out of Macondo size (lasts 50 days with a rate of 4500 cm3 per day) once in 750 years in the exploration phase. The consequence 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.
More oil companies and shipping companies are now involved in the Barents Sea, causing concern among environment groups. These companies are followed closely by the Petroleum Authority, with demands for increased safety and preparedness.
More 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). Risk vessels are defined by the Norwegian Coastal Administration as all tankers and vessels carrying hazardous and/or toxic cargo, and all vessels over 5,000 gross tons and all vessels containing radioactive materials.
Statistically, there has been a strong increase in the number of navigational accidents since 2005. There is 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 (DSB, 2013). Accidents happening closer to the shore can be challenging for coastal transport.

3) Russian part of Barents Sea

All of the above mentioned consequences are relevant for the region and should be taken into consideration. The most dangerous and discussed events possible here are oil spills and accidents with ships. The probability of such events will grow with increasing activity levels. There have been no reported fixed oil spills or accidents involving nuclear icebreakers during the last years.

Another specificity that should be mentioned is the limited transport infrastructure in many communities on the coast of the White and Barents Seas. Regular passenger transportation and freight are performed by ships. Hydro-meteorological messages are not always helpful due to large distance. The navigators are forced to rely on their experience and good skills. For example, the self-propelled pontoon “Varnek” sailed from Arkhangelsk on 21 July 2010 with 17 cargo containers and other goods amounting to 130 tons total. She 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 in 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).

There are examples of unusual rescue operations. 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 we can avoid great disaster and unwanted consequences if we cooperate during rescue and preparedness improvements. Norway and Russia have a good tradition of mutual help. It is very important in border areas. A well-known example is the Russian dry cargo vessel Viktor Koryakin, which was pushed ashore by gale force winds while anchored by the coast of the Rybachiy Peninsula, Barents Sea on December 18, 2007. There were a crew of 12 and cargo of timber on board. The vessel had been anchored waiting for the weather to improve. Only three hours after the rescue central in Banak, Finnmark received a call that a Russian cargo vessel was in trouble outside the Rybachiy Peninsula, the crew on the Sea King helicopter had rescued all twelve sailors from the vessel. During the dramatic operation the vessel broke in two.

ANALYSES OF RISK IN DIFFERENT SEA AREAS

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. Here we look into the statistics and different estimates present, and use this as a basis for qualitative risk assessments. 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. 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 perceptions of types of accidents and range of consequences are interpreted by the authors based on analytical reports and expert opinions. The following analyses in different sea areas used information presented in risk assessments by DNV GL (Paaske et al., 2014) (DNV GL, 2014c, DNV GL, 2014a); the SADA report by Steipen et al. (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. General statistics, port reports and tendencies of development of navigation have been taken into consideration for the Russian Arctic.
The use of expert opinions verifies the constructed assessments and fills up the gap of published analytical reports for the Russian region. Risk matrixes have been discussed at the MARPART project meeting in Murmansk on 10 April 2015 with different specialists: rescue and polity officers, lawyer and economists, geographers and navigators from Russia, Norway, Greenland and Island. Risk matrixes for investigated areas have been created as a result of the analysis of type of events and ship traffic features. We found the following types of events most adequate for consideration (Table 3).

Table 3. 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

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 risk matrix (Table 4-9): red area symbols high risk, yellow – modern, green – low. We distinguish risk for the environment (Table 4, 6, 8) and for people (passengers and crew) (Table 5, 7, 9).

Table 4. 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 5. 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 for grounding with cargo and other accidents, including collisions with fishing vessels.

Table 6. Risk matrix of consequences for environment in coastal Norway

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
	insignificant	minor	moderate	significant	serious

Table 7. Risk matrix of consequences for people in coastal Norway

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
	insignificant	minor	moderate	significant	serious

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 coast line. 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 control 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 recovery may also be severely hampered by bad weather, ice and snow, such as the Full City grounding in the Oslofjorden in 2009. The ship had 1100 tons of heavy fuel oil onboard. 200 tons leaked out and approximately 2500 sea birds lost their lives because of this accident. The oil spill recovery 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 onboard could have been at stake if the fire had started in heavy weather and far from the nearest harbor. 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.

Table 8. 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 9. 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

In general, the skill level of the Russian participants in maritime activity complies with international standards. At the same time, the human factor prevails as the main reason for accidents (Davydenko, 2015). In addition, there are technical risks that can occur. 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) 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).

CONCLUSION

In this study we have illuminated the development of the activity level in the High North, discussed potential risk factors and made some qualitative risk assessments. We show that there are geographical differences in the High North that have to be assessed. Taking into consideration the lack of preparedness systems in sea areas such as the Svalbard region, the consequences are significant in most cases. There is a well-developed emergency system in coastal Norway close to the mainland. However, when there are incidents with larger ships such as cruise vessels or oil installations the whole system may be put to a test. In the Svalbard region and part of the Russian Atlantic region, 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.

There is a need for more efforts as to capacities, technology development, improvement of routines and competence to reduce the probability of accidents. Also, governments should continue to discuss limitations of traffic in high risk areas. Within the new Polar code (adopted by IMO's Maritime Safety Committee (MSC), in November 2014 (IMO, 2014)) there should be special efforts from the governments in the North to implement special rules and regulations to avoid accidents, and to increase competence. Finally, there is a need for developing better search and rescue technology, oil spill response capacities in cold water areas, and not at least communication and transport infrastructure within the region for fast emergency response.

ACKNOWLEGEMENT

The authors wish to acknowledge the support from Norwegian Ministry of Foreign Affairs and the Nordland County Administration for their support via the MARPART project, and all MARPART partners for cooperation.

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