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MARITIME SAFETY IN THE HIGH NORTH – RISK AND PREPAREDNESS

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ABSTRACT

Increasing human activity in the Arctic creates great concern about possible accidents and their consequences for life and nature. The sufficient level of preparedness for emergency cases should be defined and secured. On the base of previous assessment of activity level and risk matrix and analysis of existing search and rescue resources, the estimation of preparedness system has been done. Three regions (mainland Norway, Svalbard area and Russian part of the Barents Sea) are under consideration and comparison. The international collaboration for safety on the sea is very important in the border area.

KEY WORDS: maritime; safety; risk assessment; preparedness; Arctic; navigation; accident;

INTRODUCTION

The modern development of the Arctic creates a need for understanding of the risk factors, risk mitigating tools, and adequate rescue system capacities in the different area. Safe maritime operations in the High North depend on the risk assessment, preparations and preparedness of the companies involved as well as the government. Activities in the Arctic are challenged by limited infrastructure, long distances and harsh weather conditions.

The presented work is the part of MarPART (Maritime preparedness and International Collaboration in the High North) project, where the researchers and responsible for safety organizations of all the countries of Atlantic Sector of the Arctic on the base of activity and risk estimation should find the way of cross-institutional and cross-country partnership (Nord Universitet, 2016). That is especially important on High North with rare population and limited rescue resources.

Activity and probability of accidents differ in various parts of the Arctic, due to geographical, economic and historical reasons.

In this study, we focus in particular on 3 regions: Norwegian areas around Svalbard, along the coast of mainland Norway and on West-Russian Arctic in the Barents Sea up to Novaya Zemlya (Fig.1). This sector creates the gateway to the Arctic and in the case of global warming the development here, especially on Svalbard, will serve as a model for the changing in other regions of the Arctic. Situation which we have now on Svalbard (tourist vessel with 3000 passengers on 80 ^{o}N, for example) can be repeated on Greenland, North of Canada or Franz Josef Land or Novaya Zemlya with characteristic problems. That's why our study can have global perspective and interest.

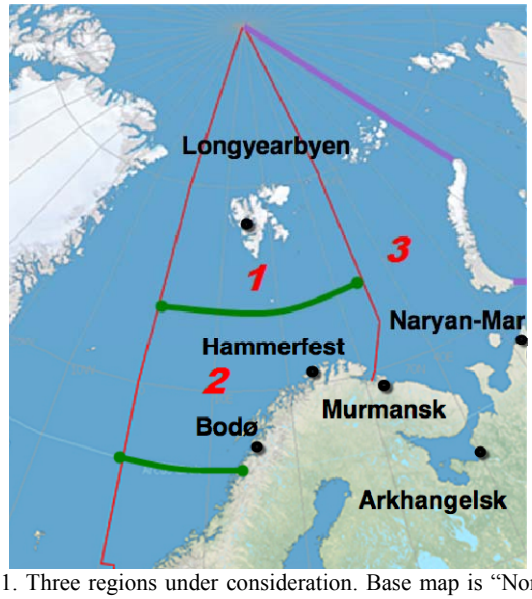

Figure 1. Three regions under consideration. Base map is "Norwegian rescue service's area of responsibility" (red lines) (BarentsWatch, 2013). Key ports and rescue centers are shown

The paper aims to analyze the rescue system resource capacities. It is necessary to discuss the preparedness system considering the volatile environment, activity levels and risks assessments done for these three regions of the High North. The article starts with describing main characteristics of the studied regions and risks for consequences from different unwanted events and different types of vessels. Then SAR resource capacity is analyzed for each area. Elaborating on crucial factors which may challenge the system capacities we discuss the main suggestions for improving SAR resource capacity and conclude about needed efforts in the preparedness system development.

THE MAIN FEATURES OF THE STUDIED REGIONS

1) Svalbard region in defined limits has area approximately 850 000 sq.km and only near 2800 population. Natural conditions characterize by long polar day and night; harsh weather with low temperature and wind during all the year and sea ice in the North. There is very small economic activity limited by fishery, tourism and coal mining in Longyearbyen, Barentsburg and Svea (mine has been closed at the end 2015, due to low coal prices). Among navigational difficulties are not sufficient charts, especially on east coast of Svalbard, reduced satellite coverage and sea ice on the North. Coal mining, fishery, tourism and science/education are the main activities on the archipelago. They provide the reasons for marine transport and determine the type of vessels needed, as well as ship traffic patterns. Ship traffic density is rather low compared to that near mainland Norway and has large seasonal variation with summer peak, but the pattern is quite stable from year to year. For example, the number of fishing vessels changes from 10-20 in January-May to 30-40 in June-August, and again to 50-60 vessels in September-December.

2) The water area of Mainland Northern Norway sector is approximately 800 000 sq.km and nearly 500 000 people leave in the region. Natural features are short period with polar night/day, strong influence of North-Atlantic current and often storms due to polar low. There is a high economic activity, rather equal activities along the region. Except fishery and shipping, oil and gas exploration and exploitation make the face of maritime life. Storms, icing, "Heavy traffic" on most common ship routes and ports are the main navigational Maritime activity is quite stable during the year without big seasonal variation.

3) Russian part of Barents Sea has area 1,400 000 sq.km and coastal population approximately 700 000 people. Polar night/day long on the North and Short on South; polar low; fading North-Atlantic current and strong influence of Arctic; sea ice, coming from Arctic Ocean and via Kara gate are the main natural features of the region. All economic activities concentrate in the South part, cargo shipping and fishery are complemented by oil/gas exploration in south-east part. The amount of vessels is quite stable during the year with seasonal increase due in summer to Northern Sea Route activity. Depending on weather and ice conditions, ships sometimes prefer the route north to the Novaya Zemlya, rounding Mys Zhelaniya (cape of Desire) to the way via Kara Gate. Respectively in such cases there are some ships in the Northern part of region.

ACTIVITY LEVEL AND RISK ASSESMENT

In (Marchenko et al., 2015) we describe the maritime activity and provide risk assessment matrixes for environment and human beings for these 3 regions. In the recent years the ship traffic in the regions continues to grow, which can be illustrated by the number of calls in the key ports. See Figure 2 and 3 as example. The difference between the amount of ships of various types is so big that only logarithmic scale allows to show the data in appropriate way. For example, for Hammerfest, passenger, fishing and offshore supply vessels have a call number hundred times more than tankers and 10 times more than refrigerators and loader ships.

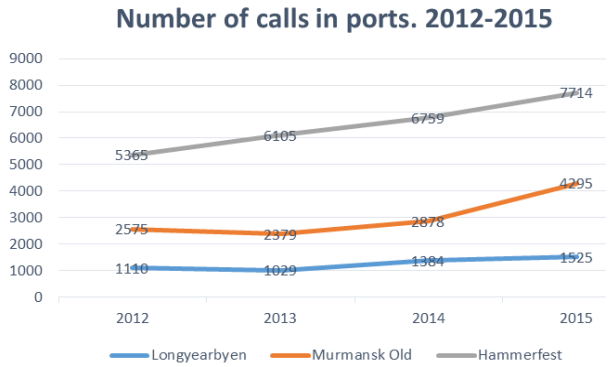

Figure 2. Number of calls on 3 ports for 2012-2015 (Kystverket, 2016)

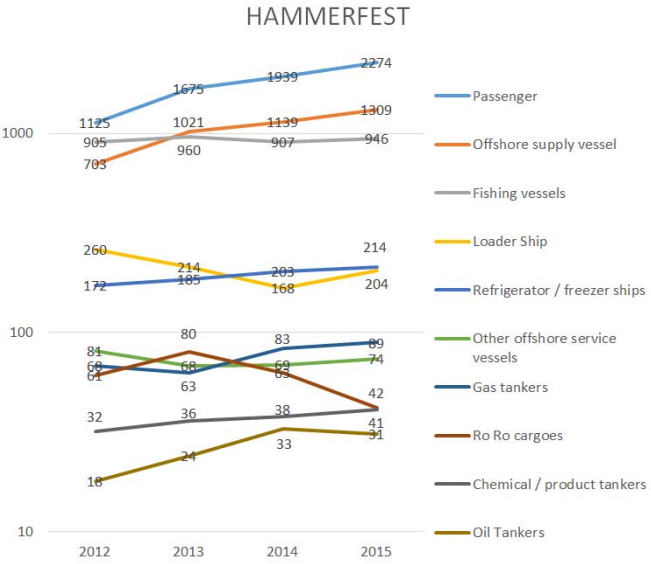

Figure 3. The amount of port calls in Hammerfest (Norway) (Kystverket, 2016)

For risk assessment (Marchenko et al., 2015) we defined three main groups of ship: 1) Tourist/Cruise ship; 2) Cargo/tanker petroleum Rigs/floaters; 3) Fishing vessels and 5 types of events:1) Grounding; 2) Collision (including sea ice); 3) Fire; 4) Violence/terror and 5) others (mostly technical problem on the ship). The combination of ship type and events will give us possible variation of accidents, f.i. grounding of cruise ship (T-G), fire on fishing boat (F-F).

The accidents statistics, AIS data , analyses of consequences (DNV GL, 2014b, DNV GL, 2014a, Sysselmannen på Svalbard, 2013, Kystverket, 2016), and expert opinions have been used for risk matrix creation, considering a risk as the amount of harm that can be expected to occur due to a specific event. The risk is then the product of the probability of accidents multiplied by the severity of consequences. We have estimated separately risk for nature and for people. For Svalbard region the risk is mostly moderate as for nature and for the people, because the low density of ship traffic and low probability of accidents. High risk is only estimated for people (passengers and crew) in case of Grounding and collision of a tourist ship: with low probability, but significant consequences; and in case of a Fire on tourist and cargo ships: with very low probability but serious consequences –.

At the Norwegian mainland coastline, the frequency of grounding and fire among fishing and cargo vessels is quite high due to the number of vessels and operations almost all year round. There is a quite heavy cargo vessel traffic along the coastline, and the probability of grounding is quite high, especially in winter.
As for risk to life, fire on board of tourist and cargo ships is a serious threat, and estimates a high risk. The probability of violent action and terror is extremely low. However, the consequences both for lives and for the environment may be disastrous.
The Russian part of the Barents Sea estimates the highest risk for environment in case of collision and fire on fishing ships and in case of grounding and fire on a tourist ship. The high risk for lives is estimated for fishing ships in case of collision and fire; for cargo ships – in case of collision and for tourist ships- in case of fire.
The matrixes we refer to are illustrated in the Tables 1 and 2.

Table 1. Risk matrix of consequences for environment in Russian part of Barents Sea. Red area symbols high risk, yellow – modern, green – low

a)

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,	
	minor	moderate	significant	serious

b)

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
	minor	moderate	significant	serious

c)

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
	minor	moderate	significant	serious

Table 2. Risk matrix of consequences for people in Russian part of Barents Sea

a)

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
	minor	moderate	significant	serious

b)

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
	minor	moderate	significant	serious

c)

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
	minor	moderate	significant	serious

SEARCH AND RESCUE (SAR) RESOURCE CAPACITY

Svalbard Area

Locating in the heart of Arctic, the main Svalbard town (Fig. 1) - Longyearbyen plays key role in SAR preparedness for the whole Western Sector of Arctic. Increasing of activities in high North makes this role more important and demands international collaborations. Svalbard Governor as a head of police and local authority is responsible for SAR service in the limit of 12 mile zone and coordinate it. Outside this limit governor can help with available resources. Governor's employees work in close cooperation with Longyearbyen Hospital, Coast Guard, Red Cross and Fire service (Sysselmannen på Svalbard, 2013, Sysselmannen på Svalbard, 2010).

In 2014 significant improvement in SAR preparedness has been done. Since April 2014 two large rescue helicopters Super Puma (instead one before) are stationed on the islands. One of helicopters has 1 hour emergency time, so it should be in 1 hour in any place inside 140 nautical mile zone from Longyearbyen with 5 men crew and eventually medical or other rescue personal. It can take 20 men on the board. 2nd helicopter has 2 hours emergency time. Lufttransport AS delivers helicopter service since 1 April 2014. There are 9 fuel depots on Svalbard, Bjørnøya, Hopen for refueling. That increases reachable area significantly. Since September 2014 the new 88 meter long, 1B ice class rescue vessel "Polarsyssel" insures SAR operation in the area during ca. 6 months per year (May-October). "Polarsyssel" has state of the art technology enabling it to engage in rescue and emergency situations under extreme Arctic conditions. Coast Guard vessels operating in Svalbard area (ice resistant Nordkapp class ships or icebreaker KV Svalbard) can be used for SAR, fire service and elimination of oil spills.

The emergence plan in case of environmental pollution was created by Governor of Svalbard in 2010 (Sysselmannen på Svalbard, 2010). It includes all key moments, organizations, necessary actions, summarizes resources.

Arctic survival kit
Hypothermia is the main issue in case of large disaster in very remote place of the Arctic. Due to long distance, the help can not arrive soon and most likely in emergency case people will need to wait for several

hours. As it is difficult to evacuate many people in distress quickly, Longyearbyen Red Cross has created Arctic survival emergency kit for 8 persons, that allowed even unexperienced people to keep warm themselves for a long time. 30 such kits, dropped by stationed in Longyearbyen plane DORNIER 228-202K can safe 240 persons, the amount, exceeding the content of average transpolar plane or adventure cruiser. With cruise speed more than 300 km/h and range more than 1000 km, during 2 hours after getting emergency signal, DORNIER 228-202K can deliver Arctic Survival kits on the distance of 200 km from Longyearbyen and reach f.i. very North of Svalbard, Franz Josef Land or Northern East of Greenland (Fig. 4). Using stantioned on mainland larger airplane such as Orion with maximum speed 750 km/h and range 9000 km, during 4 hours Arctic Survival Kits can be delivered further then North Pole, North of Ellsmere Island in Canada, North of Taymyr Peninsula and Severnaya Zemlya in Russia.

Figure 4. Area there Arctic Survival Kit can be delivered in 2 and 4 hours after getting signal. Base map is Arctic Search and Rescue Agreement Area of application illustrative map. Material - courtesy of Longyearbyen Red Cross.

Arctic Survival kits are owned, copyrighted by Longyearbyen Red Cross (LRC) and located in Longyearbyen Svalbard. It can be delivered to emergency place by helicopter, plane, ship, snowmobile. It is air droppable from long range fixed wing aircraft and was successfully tested with P-3 Orion and Dornier aircrafts.

Longyearbyen Red Cross (LRC) emergency equipment with total capacity 400 people includes Field Hospital (1 Surgery room and 4 Care Units capacity 100 people) and Emergency response unit (Tents for 150 people and 30 bags with Arctic survival kit, capacity 240 people). Each of such 30 waterproof bags contains equipment for 8 Survivors : 4 Jerven bags kings size Thermextreme, 2 Sleeping pads, 8 Bottles of water, 8 Heatpack, 1 Ready heat blanket, 1 Samsplint First-Aid Pillow.

Svalbard in general is very well equipped, but has very limited human resources. It is not possible constantly have a crew for large-scale SAR in small town as Longyearbyen. In worse case (due to seasonal migration) it could be ca.20 high qualified in SAR persons. But it case of emergency the number can rise till 100-200 owing Red Cross and to calling in students from the University Center in Svalbard (they all pass Safety course with first aid) and other skilled volunteers. Longyearbyen society is very intelligent and enthusiastic, hardened and cohesive in harsh environments.

Mainland Northern Norway

The Norwegian search and rescue service is administrated by the Ministry of Justice and Police. The operational coordination is executed by the Joint Rescue Coordination Centres (JRCC) Southern Norway and Northern Norway (JRCC, 2016). Norway coordinates rescue operations from the North Pole, along with the Greenwich Meridian to the west and to the east up to the coast of Varanger and Russian border. Northern part of Norway has a wider responsibility area than the southern, and stretches to the North from 65º north.

To manage an effective SAR response, Norwegian national preparedness system consists of services and resources administrated by public agencies, private organizations, and volunteer companies. This service covers sea, land and air rescue for vast areas of Norway and coordinates interaction and cooperation of fairly limited resources. However, the mainland Norway has a better capacity than the Svalbard area. The Joint Rescue Coordination Center Northern Norway is situated in Bodø. 20 local Rescue Coordination Centres (LRS) are placed at the police district headquarters in the mainland Northern Norway. The joint rescue coordination centers are authorized to use all available resources of government agencies (Storting, 1961 - 1962). Therefore, the rescue efforts are closely linked to public health services, the fire brigades, Norwegian Civil Defense, Police, Norwegian Coastal Administration, Air Traffic Service and the Armed Forces. This service is supported by a great number of voluntary and private organizations.

The larger operations are headed by police chief officers in Salten (Bodø). The JRCC mobilizes additional personnel - the SAR management team, extra rescue controllers and professional information officers.

As for communication and navigation resources, the 2 coastal radio stations of mainland Northern Norway are located in Bodø and Vardø. They maritime distress frequencies and provide communications for emergencies at sea (Ministry of Justice and Police, 2002). Vessel Traffic Service (VTS) in Vardø under the Norwegian Coastal Administration keeps track of vessel movements and provide navigational safety in a limited geographical area (The Norwegian Coastal Administration, 2015). Radars and meteorological sensors, Automatic Identification System (AIS) and a special reporting system for vessels traffic SafeSeaNet Norway (SSN N), Dynamic Risk Assessment (DRA) are important tools of VTS service. Also there are resources that are used for navigation purposes in SAR – differential GPS, anti-collision system AIS allowing vessels to exchange information about their flag, position, speed, course, etc, electronic navigation map ENC, Application Specific Messages (ASM) exchanging safety related data between ships, the VHF data exchange system VDES (Fjørtoft et al., 2015). In the 1980s JRCC were linked up to international satellite-based emergency communication and alerting systems and accepted additional coordination duties in connection with emergencies in distant ocean areas. Satellite detection of ships uses resources of geostationary satellites, terrestrial communications systems and Iridium (DNV GL, 2014c)

Rescue helicopters are the important lifesaving resource for SAR service in the High North. Helicopters Sea King from the №330 Squadron Royal Norwegian Air Force are operated by the Ministry of Defense and are well-equipped for all kinds of SAR operations. The Sea King helicopters are at constant alert and may be in the air within 15 minutes. Their capacity is 9715 kg, 18 passengers or 6 stretchers, and the maximum flight time of 5 hours. The main base with two Sea King helicopters is in Bodø (Forsvaret, 2016b). In Nordland there are

also one AW139 ambulance helicopter in Brønnøysund (Norsk Luftambulanse, 2013). The AW139 has capacity of 6400 kg, 12 passengers, or 2 stretchers (Finmeccanica, 2016).
There is also a base in Finnmark county with two Sea King helicopters in Banak. Also there are two EC225 helicopters (owned by Bristow) in Hammerfest and one S-92 helicopter (owned by CHC) based in Hammerfest (VG, 27.10.2012).
In Troms at the Bardufoss air base there are two Bell-412 from №339 Squadron owned by the Ministry of Defense with capacity of 5398 kg and maximum flight time of 3 hours (4,5 hours with extra fuel tank) (https://forsvaret.no/fakta/utstyr/Luft/Bell-412-SP); one AW-139 helicopter of the Royal Norwegian Air Force; and two NH90 helicopters from the 337 Squadron for the Norwegian Coast Guard with larger capacity of 10600kg, or 20 passengers or 12 stretchers and maximum flight time of 6 hours. There is also one AW-139 ambulance helicopter in Tromsø.
The estimated helicopter coverage for SAR is illustrated on Fig. 5.

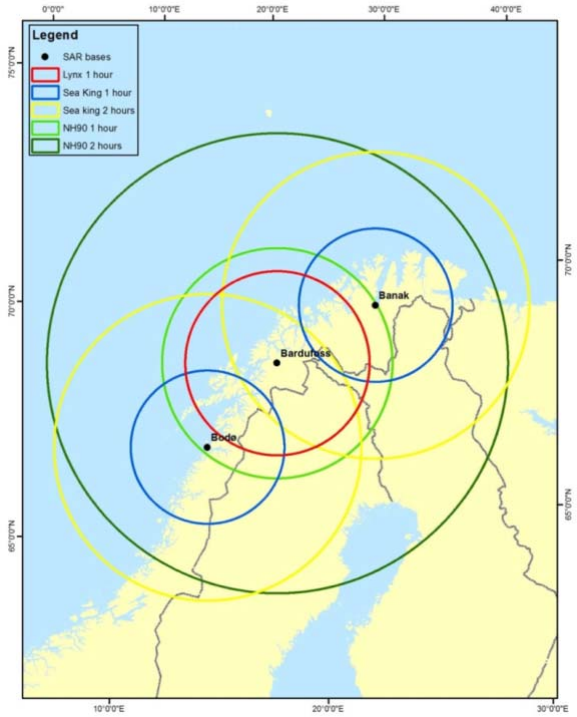

Figure 5. Estimated SAR coverage (MARINTEK, 2012)

2 surveillance aircrafts (F-16 and Orion) are available in Bodø and Andøy (DNV GL, 2014c). Ambulance aircrafts of the Northern Norway are based in Kirkenes, Alta, Tromsø, Bodø and Brønnøysund. Hospitals with different capacities are located in Mosjøen, Mo I Rana, Lofoten, Narvik, Harstad, Stokmarknes, Tromsø, Kirkenes and Hammerfest.
The Coastal Guard fleet in the mainland Northern Norway consists of 3 ice-reinforced offshore patrol vessels of Nordkapp class with helipad used for northern sea areas - KV Nordkapp, KV Senja and KV Andenes, 3 offshore patrol vessels of Barents sea class used for oil spill preparedness and one of them - KV «Sortland» - is additionally equipped to take the NATO submarine rescue system on board and can function as the Navy's underwater platform. KV Harstad with advanced capacity for oil spill preparedness has booms and bigger tank to operate further in the sea and resupply diesel to field stations around Jan Mayen, Hopen and Svalbard. Smaller vessels of Nornen- and Reine-class assist JRCC centers in SAR operations all along the Norwegian coast (Forsvaret, 2016a). In addition, Norwegian Sea Rescue Society (NSSR) vessels (40 in operation) are ready for SAR missions.
Survival in cold climate is largely dependent on survival equipment on board of vessels and rescue vessels, aircrafts, helicopters.

Russian Part of the Barents Sea

SAR forces and resources of the Russian (Eastern) part of the Barents Sea belong to different functional subsystems of Russian State. They include subsystems of the Ministry of Emergency Situations (EMERCOM); the Ministry of transport of the Russian Federation; the Border service; the Ministry of defense; the Ministry of natural resources and ecology and the State Corporation for atomic energy "Rosatom".
EMERCOM ensures the safety of people, an earlier response to emergencies in the Arctic zone and covers the whole area of responsibility for the security of the Northern Sea Route. It is planned to organize 10 specialized emergency centers located throughout the coastline of the Russian Arctic. Three of them are located in the eastern part of the Barents Sea - Arkhangelsk, Murmansk, Naryan Mar. Each Arctic Safety Center (ASC) has area of responsibility, tasks, forces and means, on the base of existing and foreseeable threats. Arctic SAR system works in a mode of constant readiness and emergency response to any emergency situations or fire. ASC includes a complex of emergency rescue information-analytical centers. ASC is equipped with all-terrain vehicles, universal emergency rescue and fire equipment, located in specialized containers. It makes possible fast loading and delivering of specialized equipment for performance of works on liquidation of consequences of emergency situations of technogenic and natural-technogenic character. EMERCOM of Russia is entrusted with analytical, information and control functions with emergency response in the Eastern part of the Barents Sea.
The Ministry of transport of the Russian Federation implements air and space search and rescue operations and ensures transport security, maintain of navigational structures. Russian Transport Ministry created a rescue sub-centre in Arkhangelsk and Maritime rescue and coordination center in Murmansk to control situation in the Eastern part of the Barents Sea. Their SAR resources are tugs – rescue, supply vessels, diving vessels and boats, rescue vessels and motor boats and auxiliary vessels and the new modern rescue vessels of unlimited area of navigation. All rescue coordination centers interact with one another.
There are several planes and helicopters belonged to Federal air transport Agency assigned to conduct Search and Rescue mission. Three planes L-410, two planes AN-26, two helicopters Mi-26 and 18 MI-8 are based in Arkhangelsk. Three of these MI-8 helicopters are constantly on duty. One cargo plane AN-30 equipped with video monitoring system is in constant readiness in Naryan Mar. Other resources of Naryan Mar base are sixteen helicopters 16 MI-8, and two of them are in constant readiness. There are seven helicopters MI-8 in Murmansk and two of them are constantly on duty.
Federal State Enterprise "Rosmorport", belonged to the Ministry of transport of the Russian Federation is to ensure the safety of navigation in water areas of sea ports. "Rosmorport" has a large group of 29 diesel-powered icebreakers. The icebreaker fleet of Russian Federation is actively developed and renovated after a long pause now.
The border departments of the FSB of Russia in the Eastern part of the Barents Sea consist of the border post "Nagurskoe" on Franz Josef Land. The border guards apart of fulfilling their direct task can provide assistance in emergency case before the other rescue units will arrive to the place of accident. Several patrol ships and boats belonged to Russian Navy can be used for assistance
The Ministry of natural resources and environment of the Russian Federation implements integrated management in the field of environment protection and natural resources, coordinating environmental activities of various ministries and departments,

industrial enterprises and organizations. The Ministry organizes public ecological assessment and widely collaborates with international environmental organizations. The Ministry interacts with Federal Hydrometeorological service, Federal Agency for water resources, Federal forestry Agency and the Federal Agency for subsoil use.

The icebreakers of the Federal state unitary enterprise "Atomflot" is intended to provide icebreaking pilotage along the NSR and in the freezing ports of the Russian Federation. Four nuclear icebreakers, one container vessel and 4 vessels of technological service are based in Murmansk and can be used in emergency case if available.

The main focus in marine preparedness in Russia is on the special rescue vessels. The group of the State Marine Rescue Service of Rosmorrechflot, based in the ports of Murmansk and Arkhangelsk. The fleet is composed of the following emergency rescue ships: the newly built multipurpose salvage vessels of the strengthened ice class "Murman", "Baltika" (asymmetric icebreaker) and "Rescuer of the Kavdeykin". In addition there are raid diving boat "Diver Pechkurov", marine rescue ship "Captain Martishkin", a marine salvage tug “Agat”, non-self-propelled floating crane "SPK-19/35" payload capacity 35 tons, as well as support floating assets (all weather rescue boats, dive boats, booms motorboats and barges). See Figure 6-8

Figure 6. Multipurpose salvage vessel "Baltika". (Rosmorrechflot, 2016)

Figure 7. Multipurpose salvage vessel "Murman". (Rosmorrechflot, 2016)

For emergency response and assistance to victims at sea in case of large-scale disasters in addition to these vessels may be involved the court of the Arctic rescue center of EMERCOM of Russia (Arkhangelsk port), and group disaster rescue force of the Northern fleet of Naval Fleet of Russia. Below is a photo of the sea rescuer of the strengthened ice class " Zvezdochka " (Fig.8). This is a head from the series consisting of four ships which are being built in Severodvinsk from 2010.

Figure 8. Marine rescuer of Northern fleet “Zvezdochka”. (Kuleshov, 2014)

Summary for the studied regions

The analyzed SAR resource capacities for the sea regions of Svalbard, mainland Norway and the Russian part of the Barents Sea are consolidated in the Table 3.

Table 3. SAR Features of the regions under considerations

Region	**1) Svalbard area**	**2) Mainland Norway Coast**	**3) Russian Barents Sea**
Area sq.km	850 000	800 000	1,400 000
Population	ca. 2800	ca 500 000	ca. 700 000
ships in the area at the same time	2 (Jan) -100 (Aug)	1200 – 1400	20-30 (winter season) 200-300 (summer navigations)
Mar. accidents per year	3-5	300-400	10-20
SAR resources:			
SAR personal	ca. 20 person	Several thousand	Sev.hundred on duty and sev.thousand can be engaged
Volunteers	ca. 50 person (RC)	Several thousand (RC + NSRS)	the number of volunteers and procedure of their involvement is not defined
Helicopters	2 (SuperPuma)+1	2 (SuperPuma) +4 (Sea King)+7 (Other)	7 on duty and 30 can be engaged.
Planes	1	2 (Orion)+5 (Ambulance)	1 on duty and 5 can be engaged
Vessels	1(Polar syssel)+1(C oast Guard)+2 (small boats)	3 (Offshore patrol) +3(Coast Guard)+ ca. 40(small boats)	2 (rescue icebreakers)+5 (Rescue Ships)+ ca. 40(small boats)

RC – Red Cross; NSRS-Norwegian Sea Rescue Society.

SUGGESTIONS FOR SAR RESOURCE CAPACITY IMPROVEMENT

Improvement of SAR resources capacity has been an urgent topic for the and there are several ways to improve resource capacity for the mainland Northern Norway. The coordination capacity of the civilian emergency preparedness system by The Ministry of Justice and Public Security and Norwegian Directorate for Civil Protection (DSB) was assessed recently by the Office of the Auditor General of Norway (Riksrevisjonen, 2015). The study shows that the national preparedness system has serious weaknesses in joint efforts from various Norwegian authorities to improve the system and in evaluating and following-up the organized emergency exercises and other events. The main recommendations for the authorities are to reinforce monitoring of the authorities' work with the national preparedness system, to improve coordination and partnership between agencies within the national preparedness system, to ensure the learning outcomes out of happened accidents and organized exercises, and to clarify responsibilities of the Ministry of Justice and Public Security and the DSB for better practice of coordination and partnership (Riksrevisjonen, 2015) Some coordination resources should be directed towards better cooperation on emergency preparedness and development of joint emergency response concepts based on the principles of shared area-based emergency response resources (DNV GL 2015). Local Rescue Centers have less resource capacity, which may lead to delays in response; therefore, the coordination should be improved (Fjørtoft et al., 2015).

As for communication and navigation resources, DNV GL (DNV GL, 2014c) suggests the improvement of satellite and navigation systems that are used for SAR operations because of their reduced capacity in the north areas. Radio signal is sometimes missing because of long distance between coverage stations, the information value is low because of lack and misinterpretation. Satellite coverage on the latitudes of coastal Norway is quite good (DNV GL, 2014c). Outside the radio coverage satellite telephones /Iridium are used. Fjørtoft et al. (Fjørtoft et al., 2015) also highlight that communication resource capacity can be limited because of lack of knowledge about alarming procedures, cultural peculiarities among different social groups, bureaucracy or language problems with foreign neighbors. The main suggestions are directed on development of satellite systems, procedures and culture for alarming.

Helicopter resources are limited for SAR purposes in the Northern Norway. Picking up people from boats west of Tromsø is challenging because Sea King helicopters from Banak and Bodo take a long time to the area (Joint Rescue Coordination Center, 2015). There is a suggestion to optimize this preparedness capacity, to enforce capacity during winter months when preparedness system is especially vulnerable and to create cooperation connection with standby vessels from oil installations for refueling helicopters (DNV GL, 2014c)

Long response time of aircrafts reduce air preparedness capacity. It is suggested to improve the availability and SAR equipment on board (DNV GL, 2014c).

Attempts should also be directed towards determining the actual environmental conditions, enhancing evacuation and rescue means, developing new rescue equipment that is suitable for tough climate, cold waters and long distances and new requirements for rescue equipment (DNV GL, 2015).

As for medical resources, the capacity can be improved by better involving hospitals in rescue service and by establishing necessary continuous communication and high quality video transmission in order to implement telemedicine, the newly discussed method, which investigates, monitors, treats and manages patients using the communication systems that provide access to expertise regardless of where the patient and expertise is geographically located (DNV GL, 2014c).

As it was shown above, Svalbard in general is very well equipped, but has very limited human resources. It is not possible constantly have a crew for large-scale SAR in small town as Longyearbyen. In worse case (due to seasonal migration) it could be ca.20 high qualified in SAR persons and usually it happens in summer, when the maximal amount of tourists visit Svalbard, and huge tourist ships with 2-3 thousand people on board are in the area. But it case of emergency the number can rise till 100-200 owing Red Cross and to calling in students from the University Center in Svalbard (they all pass Safety course with first aid) and other skilled volunteers. Longyearbyen society is very intelligent and enthusiastic, hardened and cohesive in harsh environments.

The good examples of fast mobilization and effective rescue operation are rescue of tourist cruise liners Maxim Gorky, holed by ice in Greenland Sea at 60 nautical miles west of Svalbard in 1989 and Heanseatic, grounded in Murchinsonfjorden (Northern fjord of Svalbard), 1997. During these rescue operations, 575 and 145 passengers (respectively) and large part of the crews had been safely evacuated in short time, accommodated and treated in Longyearbyen with warm hospitality.

Russian Federation has considerable resources in the Barents Sea. The main places of their dislocation are the ports of Murmansk and Arkhangelsk, Arctic Safety Centers, as well as bases of the Northern Fleet of the Russian Navy.

The sea area of Barents Sea is 1424 km^2. The arrival of rescue forces to the place of emergency in remote areas of the Barents Sea may occur in a few days. Therefore, special importance is the problem of speed of the decision making about the involvement of rescue forces, including international, with the exception of formalism when crossing state borders and defining international order of financing of expenses on implementation of emergency rescue operations and carry emergency preparedness.

CONCLUSION

In this study we have illuminated the development of the activity level in the High North, referred to risk assessments in three sea regions in the High North and analyzed SAR resources for these three regions, which form a gateway from Atlantic to Arctic. We have showed the variations of geographical characteristics,, ship traffic and preparedness capacities. We have also highlighted the main suggestions for SAR capacity improvement.

In the mainland Northern Norway the traffic levels are quite stable during year (Marchenko et al., 2015) and almost the same amount of accidents is registered along the seasons (Joint Rescue Coordination Center, 2015). Therefore, the risks of accidents frequency would be relatively the same considering *seasonality*. However, for SAR service and consequences significance, some variables are crucial. For the region of mainland Northern Norway *long distance* already west of Tromsø may cause the dynamics of risk assessments. As for navigation area factors *communication challenges* in alarming procedures and language closer to Russian border can influence the risk assessments.

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 Russian part of the Barents Sea, 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 constant monitoring and regulation 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.

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