R&D-Report

ARCTIC OIL AND GAS FIELD LOGISTICS AND OFFSHORE SERVICE VESSEL CAPACITIES

The case of the Norwegian and Russian High Arctic

Antonina Tsvetkova
Odd Jarl Borch

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Sammendrag:

I denne rapporten gjøres en gjennomgang av logistikkopplegget og leveringskjeden fra forsyningsbase på land til olje og gassfelt til sjøs på de nordligste feltene i Norge og Russland. Ulike krav til offshore servicefartøy diskuteres i lys av utfordringer knyttet til is og ising, lange distanser og begrenset infrastruktur

Emneord:

Logistikk
Forsyningskjede
Olje og gassfelt til sjøs
Arktiske farvann
Norge
Russland
Offshore service fartøy

Summary:

This report focuses on offshore logistics patterns in an Arctic environment. We provide cases from the northernmost oil and gas fields on the Norwegian and Russian continental shelf. In particular we look at the "High Arctic" defined as the Norwegian Barents Sea North and Eastwards into Russian waters, and the sea regions in the North East Passage where the cold climate and long distances to base provide special challenges.

Keywords:

Logistics
Supply chain
Offshore oil and gas fields
Arctic waters
Norway
Russia
Offshore service vessels

EXECUTIVE SUMMARY

This report focuses on offshore logistics patterns in an Arctic environment. We provide cases from the northernmost oil and gas fields on the Norwegian and Russian continental shelf. In particular we look at the "High Arctic" defined as the Norwegian Barents Sea North and Eastwards into Russian waters, and the sea regions in the North East Passage where the cold climate and long distances to base provide special challenges.

The report is made within the project "Operational logistics and business process management in high arctic oil & gas operations" (OPLOG) that focuses on the logistic value chain for offshore oil and gas activity in Arctic waters. The OPLOG project has emphasized vessel operational demands in cold climate regions, optimal combination of field and preparedness logistics and vessel configuration, innovation processes within the value chain, and business process management models that may increase logistics quality, efficiency and safety. The OPLOG project is funded by the Norwegian Research Council, Nord university and the industry partners: DOF, ENI, NSO Nor Supply Offshore, Troms Offshore and Vard Design.

Remoteness and infrastructure limitations

Most offshore fields in Norwegian and Russian Arctic have a long distance to infrastructure and are logistically a challenge due to their remoteness and rough winter conditions. There is a general lack of populated area with a well-developed service infrastructure, ports and airfields to support the complex and high tech offshore drilling and exploitation activities. Under these conditions, supply bases and their adjoined offshore supply vessels (PSV) and other offshore service vessels (OSVs) are crucial integral components of the Arctic infrastructure. The costly and high tech oil and gas field operations call for effective uplink of the oil rigs and installations with the shore capacities, where fast delivery are in demand.

More tailor-make in offshore logistics

Flexibility, robustness, functionality and speed are critical elements in the logistics chain. As the interest in exploration in Arctic waters increase, the need for OSVs fulfilling these obligations will increase. OSV design development has moved towards multifunctional roles among others within SAR and ORO, passenger transport and hotel services, helicopter hub functions, maintenance and storage. Not the least platform supply vessels (PSVs) play an important role in emergency response, including oil spill prevention and evacuation, search and rescue. The positioning and in- and outbound logistics flexibility at the supply base as well as the PSVs

capacities, are critical elements in providing resilient supply chain operations. The trend towards more multifunctional vessels has, however, to be balanced as more functions are both costly and maintenance demanding. Some functions may hamper others, for example with daughter crafts for SAR operations and oil spill response equipment reducing loading capacity.

Major development projects in the Norwegian and Russian High Arctic

This report provides an overview of 10 empirical cases to describe the context of the High Arctic, the need for offshore/onshore logistics infrastructure and the configuration of the OSV fleet. The set of the cases include 4 cases in the Norwegian Barents Sea, 4 cases in the Russian Arctic Seas: the Pechora Sea, the Kara Sea, the Laptev Sea, and 2 cases in the Russian sub-Arctic in the Sea of Okhotsk. The cases have been divided into two categories: exploration activities (mostly summer) and exploitation (all year activity). These cases illuminate what challenges and issues oil/gas companies face when developing offshore oil and gas fields in the Arctic Seas.

In addition, different types of regulations are reflected in the report in order to encompass the institutional factors, affecting field logistics operations in the Norwegian and Russian Arctic. Offshore activities in the Russian Arctic faces severe and partly extreme winterly conditions compared with the activity in the Norwegian Barents Sea South. Along the delineation line between Norway and Russia farther north in the Barents sea the exchange of joint experiences from the Norwegian and Russian shelf may be needed for a safe and efficient exploration.

Norwegian Barents Sea- still a promising oil province

The Norwegian Barents Sea is a relatively benign environment with virtually no sea ice, where exploration costs are significantly lower than everywhere else in the Arctic offshore region. Several companies regard the Norwegian Barents Sea as a promising long term oil province. Experiences from the Snøhvit and Goliat field close to shore shows that there are some winter time challenges causing delays in delivery. Going north towards the new Johan Castberg field there may be more of the same challenges. Added factors emerge in the new licenses close to Bjørnøya or at Korpfjell close to the Russian border at 74° north, especially with winter activity.

Among the oil Norwegian companies engaged in the Norwegian Barents Sea projects there are efforts to find solutions for integrated logistics cooperation sharing resources between fields. Long distances between the fields may limit the benefits of a joint fleet as to field logistics. Within emergency response logistics, there may be benefits, among others as to 2nd line emergency response. The outmost exploration fields face special challenges as to transport distances. Foggy weather is especially a threat to a safe and punctual personnel transport by helicopter. This may call for more specialized fast going personnel transport vessels and a more fine-grained pattern of helicopter and supply bases, especially located in eastern part of Finnmark.

Operations in icy waters in North-west Russia- a limited time window

The Russian Arctic shelf has remained largely unexplored for a long time: only 20 % of the Barents Sea and 15 % of the Kara Sea have been explored, while the East Siberian, Laptev and Chukchi seas have been almost not explored at all. A total of 25 reservoirs have so far been discovered on the Russian continental shelf, all of which are located in the Barents and Kara seas, including the Gulf of Ob and the Taz Estuary. Recoverable commercial reserves in the deposits amount to over 430 million tons of oil and 8.5 trillion cubic meters of natural gas

The Russian government is an active player, being both a regulator and controller of about 65 % of the petroleum sector. All significant offshore licenses are split between two state controlled companies: Gazprom and Rosneft.

In Russian waters field exploration, the main challenge is to organize full-fledged drilling operations in a very short iceless operational window until the ice period starts, foreseeing when the ice disappears and the start-up date. Lack of region-specific knowledge and ice experience is emphasized specifically as a limiting factor in managing offshore field operations in Arctic Russia. In these regions the existing port infrastructure is not adapted to the specific needs and requirements of the oil and gas industry in the High North. The quality and capacity of the industrial backup services are currently inadequate compared to what is required to match the high ambitions of the Russian offshore oil and gas industry.

Among the main Russian players involved in the development of offshore Arctic oil and gas field projects, there is a demand for multipurpose vessels which are able to operate without icebreaker escort in 1.7-meter thick drifting ice in temperatures as low as -35^{o}C. The vessels need a high maneuverability. This demand can be explained by several distinctive features related to most Russian arctic offshore fields. These are the presence of harsh ice conditions, long distances, limited infrastructure near the fields and the necessity to create basic onshore facilities for each project before its start.

For drilling operations on the Russian Arctic shelf the main Russian players are Gazprom and Rosneft, which share all offshore Artic licenses. These companies employ both Russian and foreign OSVs. For exploitation operations, both companies focus on having their own vessels built, owned by their subsidiaries and/or other Russian ship owners. There is a particular demand for OSV functionality like ice management, ice breaking capabilities, offshore hotel, hospital and maintenance support vessels, as well as emergency preparedness capabilities. The petroleum authorities play an important role in setting the standards for the bases and vessel capacities.

Joint Russian-Norwegian field exploitation

The area along the Norwegian-Russian maritime border in the Barents Sea farther up north may become an arena for potential cooperation between Norwegian and Russian stakeholders. This area is challenging due to the lack of cross-border regulation, border-crossing rules, remoteness from shore, and competition between supply bases. A joint Norwegian-Russian fleet and the flexible use of helicopter sites and supply bases at both sides of the border may provide the necessary robustness in the logistics value chain.

International regulations and operational standards in the making.

The institutional framework for maritime operations have been continuously developed, not the least after major disasters at sea related to both general maritime activity and offshore oil and gas incidents. The Polar code represents a significant step towards improved vessel standards as well as ship owner and vessel preparations for operations in ice-infested waters. The petroleum authorities include more demands as to safety and reduced risk of pollution, as well as emergency preparedness. Industry standards such G-OMO are also developed to increase safety. To avoid effects of human errors more emphasis is laid on navigational competence and bridge resource management, area experience, situational awareness, added SAR and oil spill preparedness, as well as obligatory use of pilots and/or the establishment of vessel traffic services and sailing corridors. Additional restrictions and preparedness instruments are discussed in several international bodies, including the International Maritime Organization and the Arctic Council working groups PAME and EPPR.

The Arctic shipping regulations are still at an incipient stage. Operations within the Arctic offshore oil and gas industry generate more experience step by step, improving the technology and increasing the competence for polar water operations. The IMO polar shipping regulation (via the Polar Code) is raising standards particularly through the recognition of the best way to ensure safety of navigation and offshore operations by an integrated approach among all the players involved. Sharing best practice and improving standard operating procedures will be a continuous process for the ship owners as well as the oil companies as field operators. The demands for environmental precautions and reduced "foot print" as to emission to air and sea as well as sea noise will be a continuous part of the new vessel design analyses.

Innovation focus

This report illuminates the extra vessel demands when the industry move from low Arctic to the more extreme High Arctic regions. In the Low Arctic the challenges is not sea ice but a harsh winter climate with icing and heavy winter storms, and heavy fog in summer time. The infrastructure around the supply bases are gradually improving, but will be limited. This calls for innovative solutions along the whole logistics chain. In the High Arctic the added challenges are heavy icing risks reducing the functionality of the equipment, ice bergs and multi-year ice demanding ice management and re-positioning, longer distances with need for increased speed, more vessels and more cargo capacity, and a higher focus on environmental issues with special emphasis on engine and propeller systems.

The vessel capacities have to be developed towards a higher ice class with strengthened hull and power, moving way up the scale towards ice breaker classes. This will, however, both increase the investment costs and the operating costs as well, and increase emissions. Thus, the ship owner may need assurance for an all-year and a longer term contract than normal. The winterization and increase in comfort class are also costly. The continuous reduction in emissions and sea noise is obligatory and the pressure towards implementing technology giving the lowest emission possible will continuously increase. Moving to battery and LNG-gas powered engines may cause a reduction in tank cargo capacity due to space demands for LNG-fuel and batteries. Battery charging and LNG fueling facilities must also be available at bases.

Increases in cargo and passenger capacity call for an increase the length and breadth of the vessel. A longer vessel may operate with higher speed. However, it may reduce the maneuverability in situations with high waves and strong wind in loading and discharging positioning along the rig. This calls for more thruster capacity.

The functionality as to emergency response should be at the highest and state of the art. The special High Arctic conditions call for innovations beyond the present notations when it comes to equipment that are flexible and can operate at very low temperatures and in icy conditions. The same comes to oil spill recovery equipment, where operations in icy water is a challenge. There are pro and cons as to an increased number of functions built in one vessel.

Therefore, there is a need for a discussion on multi-functionality turning towards a “multi-useless” reputation with lower operational capacity. Some tasks may be channeled into more specialized vessels tailor-made for the High Arctic region. In general, the innovation process has to take a broad view with more actors involved in taking the costs and risks of radical innovations. Close cooperation on R&D is in demand. Experience sharing on best-practice with present technology should be encouraged between the oil companies, ship owners and design companies across the borders.

CONTENT

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ABBREVIATIONS:

ERRV	Emergency Response & Rescue Vessel
HSE	health, safety and the environment regulations
IMO	International Maritime Organization
LNG	Liquefied Natural Gas
NCS	the Norwegian continental shelf
NSR	Northern Sea Route
ORO	Oil recovery operations
OSV	Offshore Service Vessel
PSA	Production Sharing Agreement
PSV	Platform Supply Vessel
SAR	Search and Rescue
UNCLOS	United Nations Convention on the Law of the Sea

1 INTRODUCTION

In this report we describe the maritime logistics operations in offshore oil and gas field projects located in the Norwegian Barents Sea and Russian North-western sea regions. The report provides an understanding of the logistics challenges that oil and gas companies meet when exploring and exploiting offshore fields in the Northern and Eastern part of the Norwegian Barents Sea and in Arctic Russia. The report also includes the institutional framework and the governmental and industrial regulations for offshore field operations.

Offshore maritime logistics operations in the value chain between the supply base and the offshore drilling and production units are defined as “upstream logistics” whose purpose is to supply the offshore drilling and production units with all necessary products, personnel and services, and to take return cargo and personnel back to shore. The end customers in upstream logistics are the offshore drilling and production units. Offshore service vessels (OSVs) have a crucial role in implementing offshore activities. We focus especially on the platform supply vessel (PSV) as the “workhorse” in offshore field logistics with cargo and in some cases passengers. These vessels are also involved in another part of the logistics, i.e. the preparedness logistics related to search and rescue and oil spill response.

This report presents examples of field operations in different Arctic environments. The field projects are located in so-called High Arctic in this report including the Norwegian Barents Sea (South and North) and eastwards into Russian waters towards the North East Passage – the Barents Sea, Pechora Sea, Kara Sea, Laptev Sea and the Okhotsk Sea. These Arctic environments differ from each other by natural conditions, offshore/onshore logistics infrastructure, companies’ activities, as well as national legislation.

We focus on different types of resources and capabilities implemented by oil and gas companies in offshore projects. We also reflect on industry regulations that sets the operational framework for the supply chain in these regions.

1.1. The oil exploration development in the Norwegian Barents Sea: an overview

The Norwegian Barents Sea is considered as a frontier petroleum province, although there have been exploration activities there for more than 30 years. The first discovery was made in the early 1980s. Since then, about 130 wildcat and appraisal wells have been drilled. It is estimated that approximately half of the undiscovered resources on the Norwegian continental shelf are in the Barents Sea.

The Norwegian part of the Barents Sea covers an area of 313 000 km^2, and is the largest sea area on the Norwegian continental shelf. The Barents Sea is also the sea area with the largest hydrocarbon potential. Only the area south of 74° 30' N is open for petroleum activities.

The only fields in production in the Barents Sea are Snøhvit and Goliat, which came on stream in 2007 and 2016 respectively. Gas from Snøhvit is transported by pipeline to the Melkøya onshore facility, where it is processed and cooled down to produce liquefied natural gas (LNG), which is delivered to the markets on special LNG vessels. Produced oil and gas from Goliat are transported onto a Floating Production Storage & Offloading (FPSO), where the oil is processed, stabilized and stored for further export in shuttle tankers, while the gas is reinjected into the reservoir.

Figure 1 below presents the main fields and discoveries in the Norwegian Barents Sea.

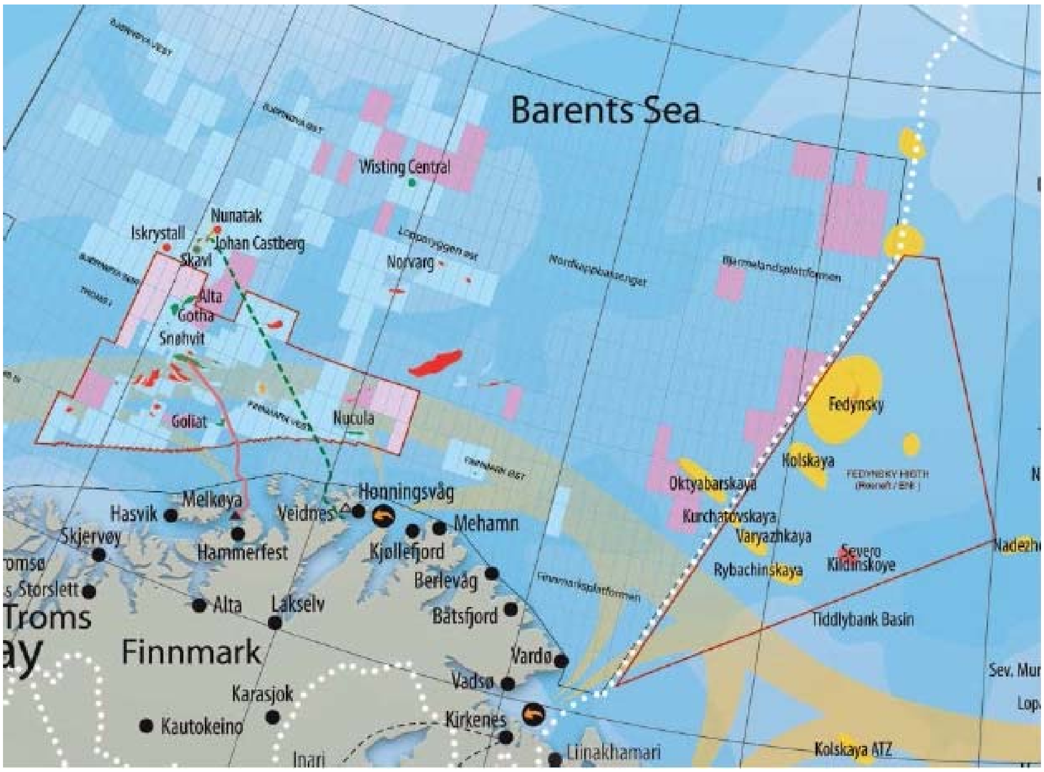

Figure 1. Fields and discoveries in the Norwegian Barents Sea (Source: The Norwegian Petroleum Directorate)

Figure #1 shows the discovered volumes in the Barents Sea by discovery year. In total 4 billion barrels of oil and gas were discovered in the province year to date where 1.8 billion barrels are liquids.[1]

[1] Available on: https://www.rystadenergy.com/NewsEvents/PressReleases/barents-sea

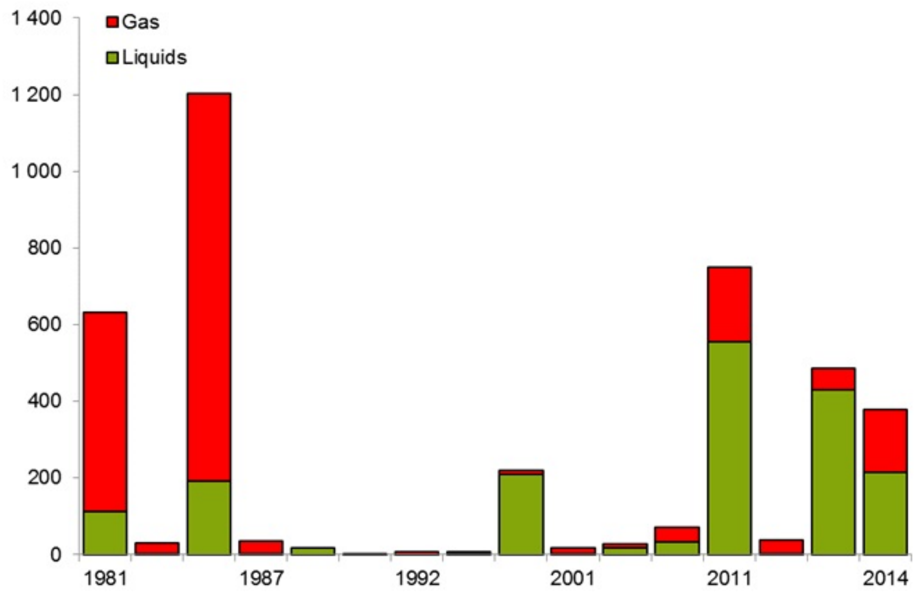

Figure 2. Discovered resources by year for the Norwegian Barents Sea, Million boe (Source: Rystad Energy Ucube)

Norwegian oil and gas companies tend to outsource their logistics activities. That means that a number of stakeholders are involved into the maritime logistics schemes for servicing and supplying offshore drilling and production units.

There is a discernible level of interest mounting in Norway's frontier Barents Sea area. New entrants coming in via the new licensing rounds in 2016 and 2017 give optimism even with fluctuating oil prices. Several companies regard the Norwegian Barents Sea as a promising long-term oil province.

"The Barents Sea is the answer…It's like going into a new country. We are only scratching the surface," – Alex Schneiter, Ludin's Chief Executive, said - *"What is missing there is the infrastructure"* (Frontier Energy, 2016, p. 8).

While the Norwegian government's belief and interest in exploration in the Barents Sea remains undiminished, new potential discoveries, like the Wisting oil field, have to be very large to go beyond breakeven. According to the analyst company Wood Mackenzie, it is primarily because of the remoteness of the location from infrastructure, expected challenging reservoir characteristics, the shareholder expectations and risk, high return on investment, severe climatic conditions and international oil prices fallen to record low levels. Despite all of this, the major oil and gas companies view Norway's frontier Arctic region as a long-term strategic move, whilst taking advantage of reduced exploration costs afforded by the Norwegian tax system in the form of a 78% tax deduction.

According to Dr. Andrew Latham, Vice president of exploration research at Wood Mackenzie, the Norwegian Barents Sea is a relatively benign environment with virtually no sea ice where exploration costs are significantly lower than everywhere else in the Arctic offshore region. He claims that costs are:

".. five to 10 times less than the cost per well offshore Greenland during 2010-2011, and more than 20 times less than the drilling costs in both in Russian and Alaskan offshore Arctic during 2014-2015" (Frontier Energy, 2016, p. 6).

In Norway, the shore-based infrastructure has been continuously developed in line with increasing oil and gas activities. The ongoing port developments in Sandnessjøen, Tromsø, Hammerfest, Honningsvåg and Kirkenes are among others established to meet the requirements from oil and gas industry. A more fine-grained set of supply and helicopter bases are expected.

1.2. The oil exploration development on the Russian Arctic shelf: an overview

While the Norwegian oil and gas field development tends to move from the South towards the North, the Russian oil and gas operations expand from onshore activities in the High North into offshore exploration of the Arctic Seas.

Figure 3. The oil/gas exploration development on the Norwegian and Russian Continental shelves (Source: CHNL)

The Soviet Union started actively developing its Arctic shelf in the early 1980s. The most promising areas of the Arctic shelf were in the Pechora and Kara seas, which are aquatic extensions of the Timan-Pechora and Western Siberian oil and gas provinces. In the period following the collapse of the Soviet Union, from 1991 to 1998, Russia's drilling fleet operated almost exclusively on the shelf of Western Europe, Asia, Africa and South America. The termination of geological exploration work in the Arctic after 1991, coupled with the loss of the Arctic drilling fleet, meant that the Russian Arctic shelf has remained largely unexplored for a long time: only 20 % of the

Barents Sea and 15 % of the Kara Sea have been explored, while the East Siberian, Laptev and Chukchi seas have been almost not explored at all.

A total of new oil and gas fields have been discovered on the Russian continental shelf, all of which are located in the Barents and Kara seas, including the Gulf of Ob and the Taz Estuary. Recoverable commercial reserves in the deposits amount to over 430 million tons of oil and 8.5 trillion cubic meters of natural gas[2].

The first and thus far only oil and gas project to be carried out on the Russian Arctic shelf is the development of the Prirazlomnoye field, which was discovered in the Pechora Sea in 1989.

Russia's Arctic development comes as its oil production increases despite a more than two-year long supply glut and plunge in prices. However, it also comes as the country's oil fields mature. As commented in April 2016 by Mikå Mered, managing partner at Polarisk, a consultancy specializing in polar issues, Russia's onshore oil and gas fields *"are depleting and depleting fast. If the Russian government wants to keep having this oil and gas, it needs to start developing offshore Arctic oil and gas fast"*[3].

The Russian government is an active player, being both a regulator and controller of about 65 % of the petroleum sector. All significant offshore licenses are split between two state-controlled companies: Gazprom and Rosneft. In total, Gazprom owns 7 licensed areas in the Barents Sea, 3 in the Pechora Sea, 13 in the Kara Sea, 8 in the Gulf of Ob and 1 in the East Siberian Sea. Rosneft owns 6 licensed areas in the Barents Sea, 8 in the Pechora Sea, 4 in the Kara Sea, 4 in the Laptev Sea, 1 in the East Siberian Sea and 3 in the Chukchi Sea. In order to fulfil its existing license obligations, Rosneft signed strategic cooperation agreements in 2011 and 2012 with Exxon Mobil, Equinor and Eni, which provide primarily joint geological exploration and development of hydrocarbon fields in the Arctic shelf.

In Russia, the existing port infrastructure is not adapted to the specific needs and requirements of the oil and gas industry in the High North. The quality and capacity of the industrial backup services are currently inadequate compared to what is required to match the high ambitions of the Russian offshore oil and gas industry.

2. THE INSTITUTIONAL ENVIRONMENT IN THE ARCTIC

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[2] Available on http://russiancouncil.ru/en/arcticoil

[3] Available on: https://www.forbes.com/sites/timdaiss/2016/08/22/a-deal-with-the-devil-russia-kicks-up-arctic-oil-drilling/#330c291c381e

The institutional environment represents a number of diverse institutions, each of which is filled with different contents and is intended to regulate the behavior of players in a certain way.

This report explores some of the main institutional regulations and pressures acting in the Arctic areas. The focus of the main institutions is on operational safety and protection of the Arctic marine environment. It is worth noting that the history of marine safety regulation is almost exclusively disaster-driven. Key safety improvements and changes in safety policies occur especially after disasters[4]. A very strict regime on maritime operations are set by the international maritime organizations, by the national maritime and petroleum authorities and by the industry itself.

2.1. Demand for legal and policy framework.

According to Article 194 of the UN Convention on the Law of the Sea (hereinafter, UNCLOS), all states involved in Arctic shipping share the responsibility for the safety of navigation and environmental protection of the region. We can observe a surge of shipping activity in Arctic waters due to thinner ice and longer ice-free summer periods, including increased offshore support vessel activity (supporting offshore exploration and extraction of oil and gas; increased destination transport (with ships moving raw materials), increased transit transportation via the Northern Sea Route (NSR). Offshore support vessel activity represents a significant form of Arctic shipping. Therefore, the harsh, environment requires more enhanced protection to mitigate additional risks imposed on shipping in polar waters. Such protection is demanded to be achieved through cooperative and preventive measures under international law and national regulation. The IMO Polar code set standards for both the vessels specifications, rescue equipment, the operational procedures and crew competence for vessels operating in ice infested waters. In Norwegian and Russian waters, the polar code area is defined as the Northern part of the Norwegian Barents Sea south of Bjørnøya at N73°31’ E 19° through a great circle line down to at Cap Kanin Nos north east of Arkangelsk at N68°38’ E43°23’. That means that some of the new promising petroleum resource areas are within the Polar code area. This calls for vessels with Polar code certificate involving significant hull strengthening, winterization, procedures and competence as shown in section 2.2.2.

[4] From a book titled “Until the Sea Shall Set Them Free” by Robert Frump, Pulitzer Prize nominee.

2.2. International institutions and their instruments.

IMO International Maritime Organization: The International Maritime Organization (IMO) is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships. This organization is globally responsible for addressing safe, secure, and environmentally sound maritime navigation.

The purpose of the IMO is to facilitate cooperation among governments on regulations and practices related to technical matters affecting shipping engaged in international trade.

The main activity within the IMO, associated with maritime safety in the Arctic, is the work on the Polar Code.

PAME: The Arctic Council's Working Group on the Protection of the Arctic Marine Environment (PAME)[5] complements the role of the IMO. This working group is the focal point of the Arctic Council's activities related to the protection and sustainable use of the Arctic marine environment and provides a unique forum for collaboration on a wide range of activities in this regard.

PAME has a mandate to address marine policy measures and non-emergency pollution prevention and control measures such as coordinated strategic plans, developing programs, assessments and guidelines related to the protection and sustainable development of the Arctic marine environment from both land and sea-based activities.

The PAME Working Group provides a unique forum for collaboration on a wide range of Arctic marine environment issues. One of the most significant tasks by this forum is to raise awareness of the Polar Code's provisions amongst all those involved in or potentially affected by Arctic marine operations, including ship owners and operators, Flag, Port and Coastal States, classification societies, marine insurers, financial institutions funding Arctic activity, and indigenous and local communities. It is intended to promote effective implementation of and compliance with the Polar Code. The Arctic Shipping Best Practice Portal provides information needed to comply with the Polar code.

The PAME working group is also working with additional precautions as to environmental protection to avoid pollution and negative impact on life in the Artic. This also includes sea noise disturbing seal and whale populations.

[5] PAME is one of six Arctic Council working groups. It was first established under the 1991 Arctic Environmental Protection Strategy and was continued by the 1996 Ottawa Charter that established the Arctic Council. For more information, see: http://pame.is/

PAME released ***the Arctic Offshore Oil and Gas Guidelines*** in 2009. The Guidelines are intended to be of use to the Arctic nations for offshore oil and gas activities during planning, exploration, development, production and decommissioning to help secure common policy and practices.

According to the Arctic Offshore Oil and Gas Guidelines, Arctic offshore oil and gas activities should be based on the following principles[6]:

1. Principle of the Precautionary Approach – refers to Principle 15 of the Rio Declaration. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.
2. Polluter Pays Principle - National authorities should endeavor to promote the internalization of the application of the polluter pays approach as reflected in Principle 16 of the Rio Declaration. The polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.
3. Continuous improvement - All parties should continually strive to improve health, environment and safety by identifying the processes, activities and products that need improvement, and implement necessary improvement measures.
4. Sustainable Development - In permitting offshore oil and gas activities Arctic governments should be mindful of their commitment to sustainable development.

The goal was to assist regulators in developing standards, which are applied and enforced consistently for all offshore Arctic oil and gas operators.

EPPR: The Emergency Prevention, Preparedness and Response Working Group (EPPR) addresses different aspects of prevention, preparedness and response to environmental emergencies in the Arctic. Members of the Working Group exchange information on best practices and conduct projects to include development of guidance and risk assessment methodologies, response exercises, and training.

The goal of the EPPR Working Group is to contribute to the protection of the Arctic environment from the threat or impact that may result from an accidental release of pollutants or

[6] Available at: https://pame.is/images/03_Projects/Offshore_Oil_and_Gas/Offshore_Oil_and_Gas/Arctic-Guidelines-2009-13th-Mar2009.pdf

radionuclides. In addition, the Working Group considers issues related to response to the consequences of natural disasters.

EPPR have prepared several reports, which are also relevant for oil and gas activity:

- Field Guide for Oil Spill Response in the Arctic Waters, 1998.
- Standardization as a Tool for Prevention of Oil Spills in the Arctic, 2015.
- Circumpolar Map of Resources at Risk from Oil Spills in the Arctic, 2002.
- Arctic Shoreline Clean-up Assessment Technique (SCAT) Manual, 2004.
- Behavior of oil and other Hazardous Substances in Arctic waters (BoHaSA), 2011.
- Guidelines and Strategies for Oily Waste Management in the Arctic Region featuring the Oily Waste Calculator Tool, 2009.

EPPR also maintains liaison with the oil industry and other relevant organizations with the aim of enhancing oil spill prevention and preparedness in the Arctic[7].

2.2.1. International and regional conventions

The International Convention for the Safety of Life at Sea (SOLAS):

The most famous disaster of all, the Titanic, with 1,517 dead, struck the first blow for real international cooperation on safety regulations, resulted in the International Convention for the Safety of Life at Sea (SOLAS), adopted in 1914. The primary safety book from which most other policies and regulations sprang, SOLAS is updated on a regular basis and is considered the safety bible for the maritime industries.

SOLAS is an international maritime treaty, which requires Signatory flag states to ensure that ships flagged by them comply with minimum safety standards in construction, equipment and operation. The current version of the SOLAS Convention is the 1974 version, known as SOLAS 1974, which came into force on 25 May 1980. As of March 2016, SOLAS 1974 has 162 contracting States, which flag about 99% of merchant ships around the world in terms of gross tonnage.

The International Convention for the Prevention of Pollution from Ships (MARPOL):

[7] For more information, see: https://arctic-council.org/eppr/about-eppr/

The Torrey Canyon oil spill off French and the south-west coast of the United Kingdom coasts in 1967 was one of the world's most serious oil spills[8] that led to the International Convention for the Prevention of Pollution from ships (MARPOL) in 1973[9].

MARPOL establishes a system of international standards for on board multi-waste management and eventual discharge. It is expected to play an important role in the protection of the Arctic marine environment. Mandatory technical rules and procedures of MARPOL are found in the six annexes, which respectively deal with the prevention and control of pollution by oil (I), noxious liquid substances (II), harmful substances in packaged form (III), sewage from ships (IV), garbage from ships (V), and air pollution from ships (VI).

The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations. As of February 2014, both Norway and Russia have ratified all the six annexes of the MARPOL.

Amendments to MARPOL and SOLAS:

The Amoco Cadiz tanker ran aground due to a steering gear failure on March 16, 1978, three miles from the coast of Brittany, France. It split in three before sinking, creating the largest oil spill of its kind in history to that date – 1.6 million barrels[10]. In 1978, it was estimated to have caused US$250 million in damage to fisheries and tourist amenities.

Public outcry and political pressure resulted in significant updates to both MARPOL and SOLAS, and the addition of safety and pollution audits that led to in 1982 to the Paris Memorandum of Understanding (Paris MoU), which established Port State Control. Port state control enabled an international port inspection system that makes it impossible for non-compliant ships to hide. It also led to the International Convention on the Standards of Training, Certification and Watchkeeping for Seafarers (STCW) in 1978.

The International Convention on the Standards of Training, Certification and Watchkeeping for Seafarers (STCW):

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[8] It was an oil spill with an estimated 25–36 million gallons (94–164 million litres) of crude oil spilt. Attempts to mitigate the damage included the bombing of the wreck by aircraft from the Royal Navy and Royal Air Force. Hundreds of miles of coastline in Britain, France, Guernsey, and Spain were affected. For more information, see https://en.wikipedia.org/wiki/Torrey_Canyon_oil_spill.

[9] According to Simon Bennett, Director External Relations for the International Chamber of Shipping (ICS), *"In the same way the Titanic led to the development of safety regimes, the Torrey Canyon stimulated the development of international environmental regulations"* (available at: https://www.marinelink.com/news/regulation-disasters371542)

[10] For more information, see https://en.wikipedia.org/wiki/Amoco_Cadiz_oil_spill

The STCW Convention was the first to establish on an international level in 1978. Previously the standards of training, certification and watchkeeping of officers and ratings were established by individual governments, usually without reference to practices in other countries. As a result, standards and procedures varied widely, even though shipping is the most international of all industries.

The Convention prescribes minimum standards relating to training, certification and watchkeeping for seafarers, which countries are obliged to meet or exceed.

One of the main updates in the STCW was the requirement for Parties to the Convention to provide detailed information to IMO concerning administrative measures taken to ensure compliance with the Convention. This represented the first time that IMO had been called upon to act in relation to compliance and implementation - generally, implementation is down to the flag States, while port State control also acts to ensure compliance[11].

The 1990 International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC):

OPRC sets out a framework for cooperative measures in relation to pollution incidents involving oil. Parties to the OPRC are required to establish measures for dealing with pollution incidents, either nationally or in co-operation with other countries.

Ships are required to carry a shipboard oil pollution emergency plan. Operators of offshore units under the jurisdiction of Parties are also required to have oil pollution emergency plans or similar arrangements, which must be coordinated with national systems for responding promptly and effectively to oil pollution incidents.

Ships are required to report incidents of pollution to coastal authorities and the convention details the actions that are then to be taken. The Convention calls for the establishment of stockpiles of oil spill combating equipment, the holding of oil spill combating exercises and the development of detailed plans for dealing with pollution incidents.

Parties to the convention are required to provide assistance to others in the event of a pollution emergency and provision is made for the reimbursement of any assistance provided[12].

Both Norway and Russia are parties to the OPRC.

The Arctic Oil Spill Preparedness and Response Agreement:

[11] For more information, see http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Standards-of-Training,-Certification-and-Watchkeeping-for-Seafarers-(STCW).aspx

[12] For more information, see http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Oil-Pollution-Preparedness,-Response-and-Co-operation-(OPRC).aspx

This is a legally binding agreement on cooperation on Marine Oil Pollution Preparedness and Response in the Arctic, which was signed by all the Arctic member states under the auspices of the Arctic Council in May 2013. The purpose of the agreement is to strengthen cooperation, coordination and mutual assistance among the Parties on oil pollution preparedness and response in the Arctic in order to protect the marine environment from oil pollution. The agreement also emphasizes regularly conducting joint training and exercises, as well as joint research and development.

The Arctic Aeronautical and Maritime SAR Agreement:

This is the first international agreement, which was prepared exclusively for the Arctic region and signed in 2011. The SAR-Agreement is the first legally binding agreement established under the auspices of the Arctic Council and covers search and rescue of aeronautical and maritime vessels and passengers. The objective of the SAR-agreement is to strengthen the search and rescue cooperation and coordination in the Arctic[13].

Guidelines for Offshore Marine Operations (G-OMO):

G-OMO is designed to offer a standard global approach to, and encourage good practice in, and safe vessel operations in the offshore oil and gas industry. This international document supersedes and replaces the North West European Area (NWEA) Guidelines for the Safe Management of Offshore Supply and Rig Move Operations, developed in 2006 as a joint project between maritime and offshore organizations in Denmark, the Netherlands, Norway and the UK. Best practice and experience exchange are basis for these guidelines and the aim has been to develop a guideline worth using worldwide.

It particularly relates to the activities: operations of offshore facilities and operations of vessels[14].

2.2.2. The Polar code

An important initiative for creating special regulation on vessel design, equipment, and operations in Arctic waters was the disaster of Exxon Valdez off the coast of Alaska in 1989[15].

[13] For more information, see https://oaarchive.arctic-council.org/handle/11374/531
[14] For more information, see http://www.g-omo.info/?page_id=2
[15] The Exxon Valdez, an oil tanker owned by Exxon Shipping Company struck the reef in Prince William Sound, Alaska, March 24, 1989 and spilled 10.8 million US gallons (260,000 bbl; more than 37,000 tonnes) of crude oil over

This ecological disaster led to the first Port state establishment of policy with international repercussions – the Oil Pollution Act (OPA) of 1990, which mandated that all tankers entering U.S. waters were to be double hulled. This requirement became the rule internationally, especially after two more accidents with Prestige (2002) and Erika (1999) off the northwest coast of France and Spain, leading to the European equivalent of OPA90 and massive acceleration of phasing out single-hulled tankers.

At the same time, the disaster of Exxon Valdez prompted the IMO to start working on a code for navigation in polar waters. Taking into account the fact that ships operating in the Arctic environment are exposed to unique risks, the intention by the IMO was not only to create a harmonized regulation for Arctic shipping, but also to promote standards for safety of navigation and recognize that the best way to do this would be by an integrated approach.

Before 2017, the IMO used such a regulatory instrument as Guidelines for ships operating in Polar Waters. The IMO-guidelines were non-mandatory, serving merely as recommendations. To become legally binding, the IMO-guidelines depended on the individual states implementing the regulations in their national legislation.

The International Code for Ships Operating in Polar Waters or Polar Code was adopted by IMO in 2014. The Polar Code was introduced through amendments to the IMO Safety of Life at Sea Convention (SOLAS) and the IMO Convention for the Prevention of Pollution from Ships (MARPOL). The Polar Code is intended to cover the full range of shipping-related matters relevant to navigation in waters surrounding the two poles – ship design, construction and equipment; operational and training concerns; search and rescue; and, equally important, the protection of the unique environment and eco-systems of the polar regions. Thereby, the Code supersedes the current IMO Arctic Shipping Guidelines and the IMO Polar Shipping Guidelines. This document reflects the concerns of the shipping industry regarding the sensitivity of the ecosystems in the Arctic and the Antarctic, and therefore, the need for a higher degree of care when navigating polar waters.

The Polar Code entered into force on 1 January 2017. This marks an historic milestone in the IMO's work to protect ships and people aboard them, both seafarers and passengers, in the harsh environment of the waters surrounding the two poles.

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the next few days. It is considered to be one of the most devastating human-caused environmental disasters. During the first few days of the spill, heavy sheens of oil covered large areas of the surface of Prince William Sound (Wikipedia's source).

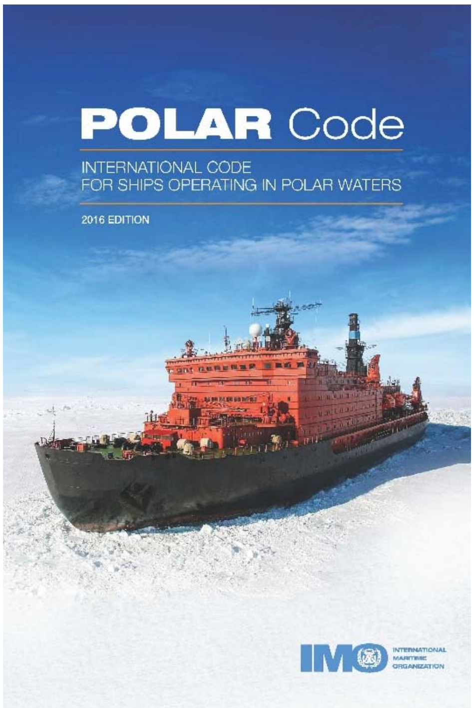

Figure 4. The Polar Code cover (Source: IMO)

The Polar Code includes mandatory measures covering safety part (part I-A) and pollution prevention (part II-A) and recommendatory provisions for both (parts I-B and II-B).

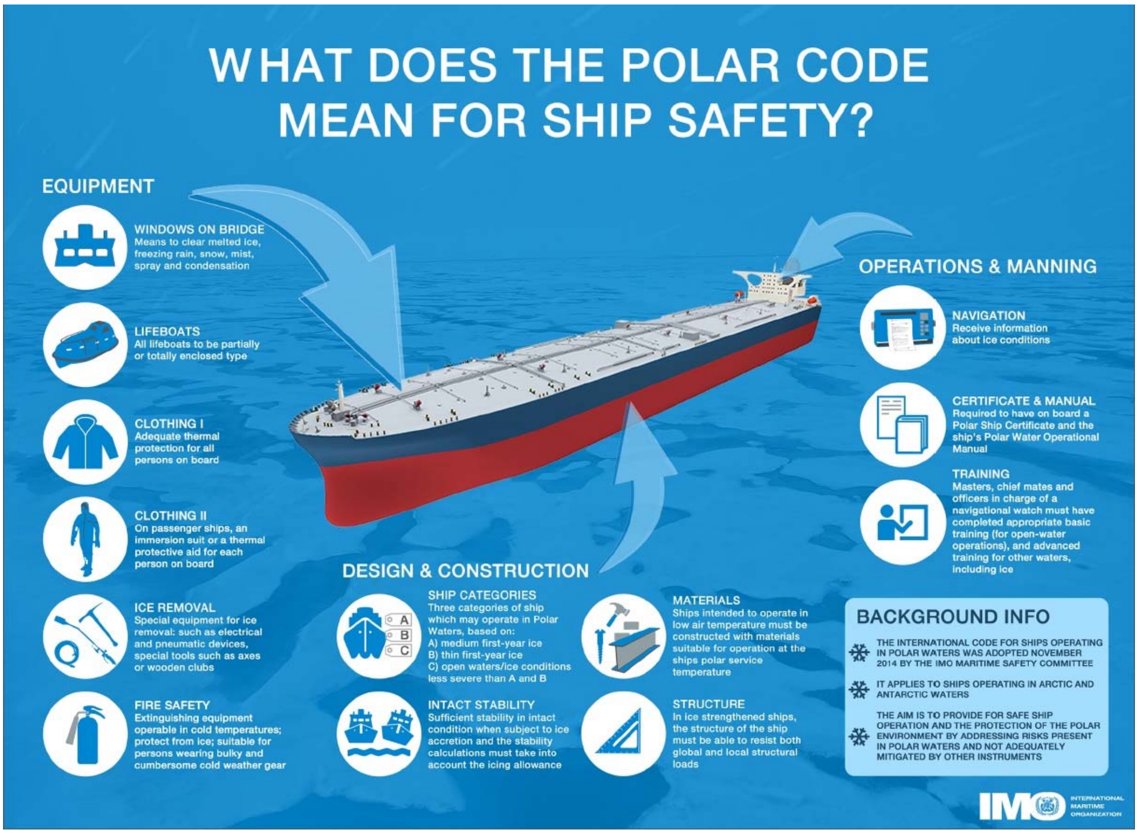

Figure 5. The safety requirements of the Polar Code – What does the Polar Code mean for ship safety? (Source: IMO).

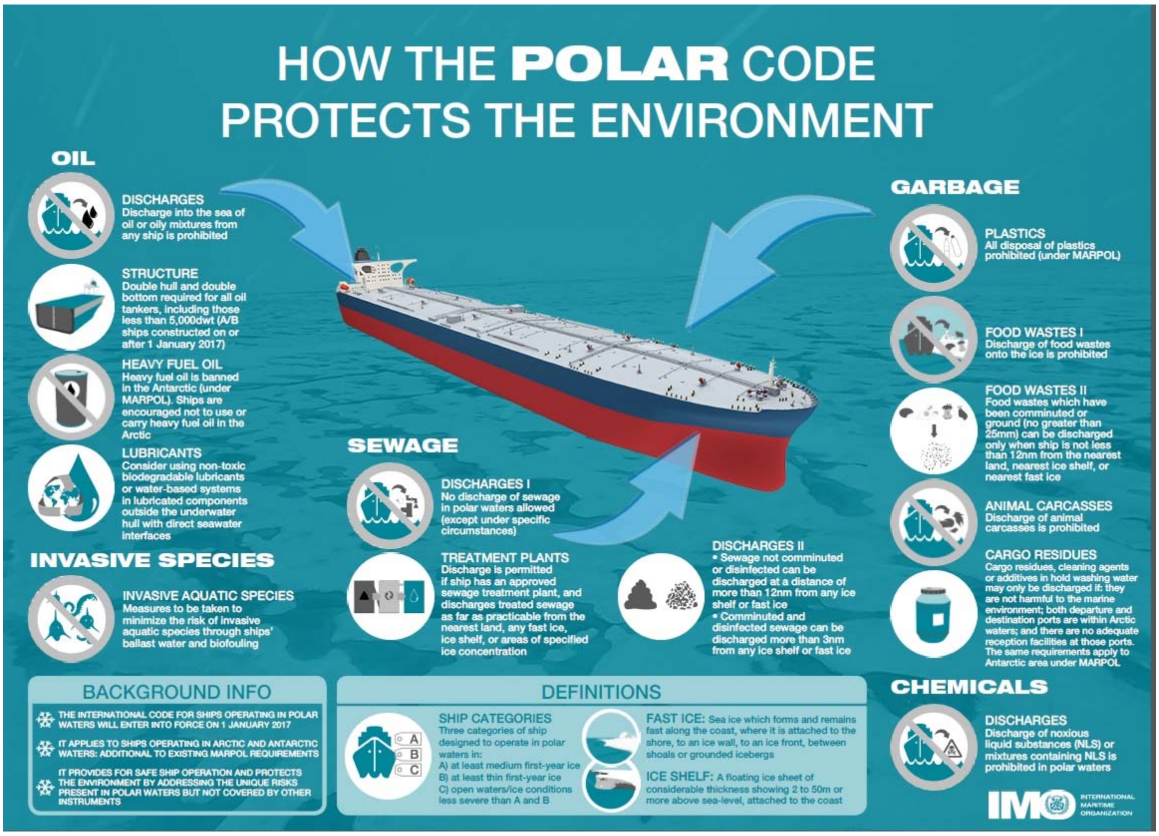

Figure 6. The environmental requirements of the Polar Code - How does the Polar Code protect the environment? (Source: IMO).

The Code requires ships intending to operate in the defined waters of the Antarctic and Arctic to apply for a Polar Ship Certificate, which would classify the vessel as:

- Category A ship - ships designed for operation in polar waters at least in medium first-year ice, which may include old ice inclusions;

- Category B ship - a ship not included in category A, designed for operation in polar waters in at least thin first-year ice, which may include old ice inclusions;

- Category C ship - a ship designed to operate in open water or in ice conditions less severe than those included in Categories A and B.

The issuance of a certificate would require an assessment, taking into account the anticipated range of operating conditions and hazards the ship may encounter in the polar waters. The assessment would include information on identified operational limitations, and plans or procedures or additional safety equipment necessary to mitigate incidents with potential safety or environmental consequences.

The chapters in the Code set out goals and functional requirements, including:

- ship structure; stability and subdivision; watertight and weathertight integrity; machinery installations; operational safety; fire safety/protection; life-saving appliances and arrangements; safety of navigation; communications; voyage planning;

manning and training; prevention of oil pollution; prevention of pollution form from noxious liquid substances from ships; prevention of pollution by sewage from ships; and prevention of pollution by discharge of garbage from ships.

It is worth noting also that the Polar Code (Chp.12) contains mandatory requirements for the training and qualifications of masters, chief mates and deck officers on ships operating in polar waters to be done by companies. The training requirements become mandatory under the Watchkeeping for Seafarers (STCW) Convention and the STCW Code from 1 July 2018.

According to the interviewee of Norwegian shipping company #1:

"In September 2017 we already have Polar Code training to get deck officers certified by the 1st of July 2018. Within our company, we started training other crewmembers as well. So, we are going to train the crews, vessel offices and private officers. We use virtual reality simulator training and class studies at school, not in real conditions, because it's too much expensive to do training in the Arctic conditions – that's enough for the Polar Code certification."

At the same time, with regard to ship certification, the interviewee of the Norwegian vessel-designer stated that they do not plan to go for certification of vessels as to the Polar Code at this moment:

"We don't see the cost benefit as it is now. We think that the characteristics of our vessels like the ice class and winterization are sufficient for the possibilities that we have in the Barents Sea,".

As told by the interviewee of Norwegian oil company #1:

"We use different types of vessels for operations in the High Arctic, in the Norwegian Sea and in North Sea. We find a vessel that is suitable for the operation. We can look for a vessel with both an oilrec class and standby class.

2.2.3. The Arctic SAR Agreement

The SAR-Agreement is the first legally binding agreement established in 2011 by the Arctic Council. It covers search and rescue of aeronautical and maritime vessels and passenges. The objective of the SAR-agreement is to strengthen the search and rescue cooperation and coordination in the Arctic.

Each member state was given a particular search and rescuw area, for which it is responsible in order to ensure immediate responses and effiicient operations (See Figure 7).

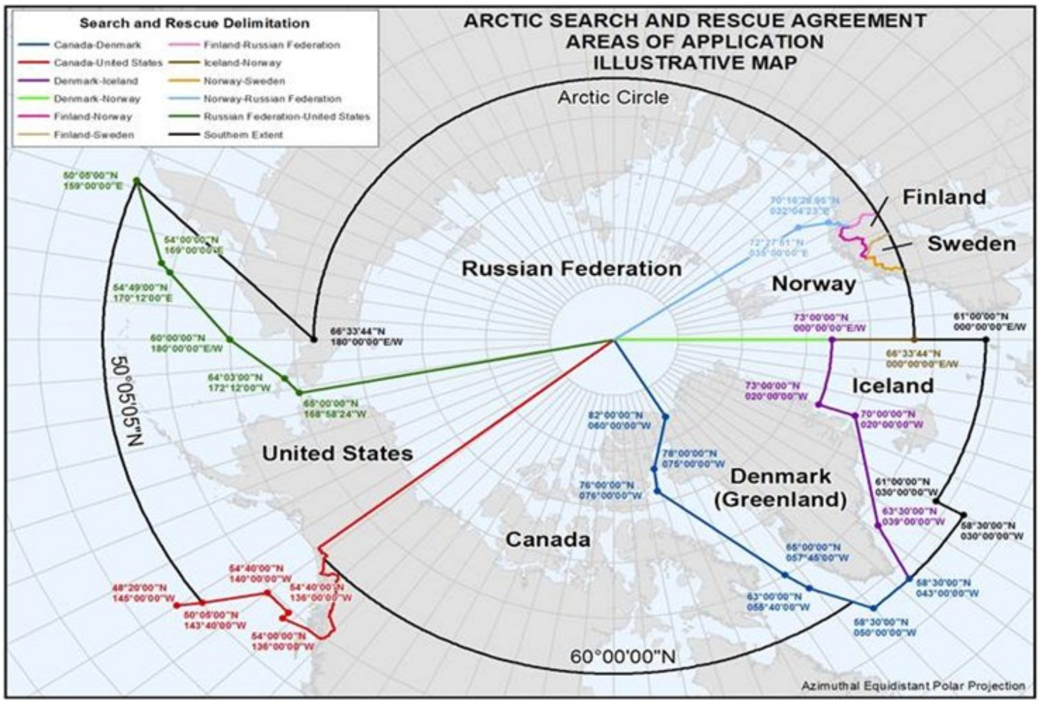

Figure 7. Arctic SAR-Agreement areas (Source: CHNL)

2.2.4. Summary

Maritime regulatory history has been frequently reactive rather than anticipatory, in particular regarding changes in marine safety, which often has been disaster-driven.

The figures from both the "Safety and Shipping 2011-2012" report by Allianz Global Corporate & Specialty, the International Union of Marine Insurance, and the 2012 report "15 Years of Shipping Accidents: A Review for WWF", by Southampton Solent University, have shown that the extent of severe marine accidents is decreasing. The next step in developing marine regulation is expected to be done in targeting the human factor as a key element for the future of marine safety. Despite aging ships, bad weather conditions, high sea traffic and runaway cargoes aside, it is estimated that 80-85% of all marine accidents can be traced back to human error. One such step is a focus on bridge resource management competence for navigators, the obligatory use of pilots in challenging waters, and vessel traffic services (VTS) guiding the traffic.

However, the Arctic shipping regulation is still at an incipient stage, being interactive and adaptive. With demanding operations within the Arctic offshore oil and gas industry more experience is gained step by step improving the technology and increasing the competence for polar water operations. The IMO polar shipping regulation (via the Polar Code) is raising standards of "polar worthiness", particularly through the recognition of the best way to ensure safety of navigation and offshore operations by an integrated approach among all the players involved.

2.3. Regulatory framework in Norway

The majority (about 80%) of Norway's oil and gas production is controlled by one company – Equinor ASA – which is 67% owned by the government of Norway. It has facilitated in setting up a strong and centralized regulatory structure, as well as public-private coordination.

The regulatory framework for petroleum activities has been designed to give the best possible balance between the companies' and the authorities' interests. This is achieved among other things through taxation policy, through the Petroleum Act and through the authorities' oversight of resource management.

Norway has established a division of roles and responsibilities between the state and the business sector. The authorities regulate the sector by setting a clear and predictable overall framework. The oil companies and other actors in the industry are responsible for the operational activities and following up on safety measures as well as emergency preparedness.

2.3.1. The Norwegian authorities.

The authorities, which have the main responsibilities in relation to offshore oil and gas industry, as well as to offshore oil spill preparedness and response include:

The Ministry of Petroleum and Energy (MPE):

The MPE holds broad responsibility over managing the state's natural resources. It is also a key institution for promoting sustainable regulation.

The Petroleum Act (Act of 29 November 1996 No. 72 relating to petroleum activities) provides the general legal basis for sound resource management, including the licensing system that gives companies rights to engage in petroleum operations. The Act establishes that the Norwegian state has the proprietary right to subsea petroleum deposits on the Norwegian continental shelf.

The Norwegian Maritime Directorate (NMD):

NPD serves as an advisory body to the MPE. It has administrative authority over resources in the Norwegian shelf.

- Coordination of matters related to safety of life, health, material values and the environment on vessels flying the Norwegian flag and foreign ships in Norwegian waters;

- Ensuring the legal protection of Norwegian-registered ships and registered rights in those ships.

The Norwegian Coastal Administration (NCA):

- coordination of all contingency organizations into one national emergency response system;
- Maintenance of preparedness and response to acute pollution which is not covered by private or municipal contingency plans. Mainly this consists of response to oil spills from ships and shipwrecks or unknown sources. If the responsible polluter is incapable of taking action, the NCA can take over the responsibility for the operation.
  - Inspection and control measures relating to pollution and waste;
  - International cooperation on responding to acute oil spills

The Petroleum Safety Authority (PSA):

This is the primarily regulatory body responsible for technical and operational safety, including emergency preparedness and working environment.

- Regulation of technical and operational safety, including emergency preparedness, at the all phases of the industry (planning, construction, operation, removal);
- Stipulation and supervision of compliance with HSE regulations
- Supervision of operator's HSE management system which is established pursuant to the petroleum HSE regulations
- Cooperation with foreign and national safety regulators

The Norwegian Petroleum Safety Authority (PSA) has consequently pronounced “The far North” as a main priority, emphasizing operator collaboration as a key to success.

The Norwegian Petroleum Directorate (NPD):

The NPD is a flexible expertise organization. There are no sections or departments in the NPD, but about 80 teams with designated mandates and defined tasks.

There are about 230 employees joining and leaving teams; and they largely control how to distribute their time in the different teams themselves.

- Contribution to creating the greatest possible values for the Norwegian society from the oil and gas activities through prudent resource management based on considerations for safety, emergency preparedness and the external environment.

Prudent resource management, which is a primary consideration in the petroleum activities, ref. Sections 1-1 and 1-2 of the Petroleum Act, includes tasks related to: Resource and factual basis; Scientific research and exploration; Development and operations; Cessation/disposal; External environment; Emergency preparedness.

- Management and further development of knowledge concerning the petroleum resources on the Norwegian continental shelf. This is a key aspect both as regards the opening of new areas for petroleum activities and in the award of new production licenses.
- Opening of new areas (Section 3-1 of the Petroleum Act)
- Granting of exploration license Section 2-1 of the Petroleum Act)
- Award of production license (that gives the licensee an exclusive right to explore for and produce petroleum) (Section 3-3 of the Petroleum Act)
- Approval of plans for development and operation of fields (PDO) (Section 4-2 of the Petroleum Act)
- Permission to install and operate installations (PIO) (Section 4-3 of the Petroleum Act)
- Production permits (Section 4-4 of the Petroleum Act)
- Decisions on disposal (Sections 5-1 and 5-3 of the Petroleum Act)

The Norwegian Environment Directorate (NED):

- Sets requirements for emergency oil spill preparedness in municipal and private sector and supervision of compliance with them;
- Monitoring of pollution from petroleum industry on the Norwegian continental shelf;
- Development of regulations and guidelines for prevention of and response to acute pollution;
- In case of acute oil pollution provides expert advice on environmental issues;
- Participation in international environmental cooperation

2.3.2. The Licensing system and Awards in Predefined Areas (APA)

State management and control of the industry is ensured through an extensive legislation that requires companies to obtain licenses and approval from the competent authorities for all phases of petroleum activities.

The Petroleum Act (Act of 29 November 1996 No. 72 relating to petroleum activities) provides the general legal basis for sound resource management, including the licensing system that gives companies rights to engage in petroleum operations. The Act establishes that the

Norwegian state has the proprietary right to subsea petroleum deposits on the Norwegian continental shelf.

Production licenses are normally awarded through licensing rounds, in which the Ministry announces that companies can apply for production licenses in certain geographical areas (blocks)[16]. The announcement procedures, who can apply, the content of applications and application procedures are governed by Chapter 3 of the Petroleum Act and Chapter 3 of the Petroleum Regulations.

Two types of licensing rounds have been established to ensure adequate exploration of both mature and frontier areas of the NCS – through the numbered licensing rounds or the system of awards in predefined areas (APA). The numbered licensing rounds include frontier parts of the NCS, where there is limited knowledge of the geology, greater technical challenges than in mature areas and a lack of infrastructure. They are normally held every other year. The Awards in Predefined Areas (APA) comprise the mature parts of the shelf, where petroleum activities have been in progress for many years with known geology and well-developed or planned infrastructure. They are announced every year[17].

Companies wanting to pursue petroleum operations on the NCS must be qualified as a licensee or operator. A prequalification process is provided to assess whether applicants meet government requirements and guidelines[18]. During an opening process, all relevant arguments for and against petroleum activities in the area in question are taken into account.

Figure 8 gives an overview of the status of the Norwegian continental shelf as of May 2017. The green areas have been opened for petroleum activity by the Storting (Norwegian parliament). The yellow areas have also been opened, but are subject to special arrangements as described in the white paper "An industry for the future – Norway's petroleum activities". The areas outlined in red are covered by the system of awards in predefined areas (APA).

21 June 2017, the Ministry of Petroleum and Energy (MPE) announced the 24th licensing round. In this round, 102 blocks/parts of blocks will be announced, divided among 9 in the Norwegian Sea and 93 in the Barents Sea (see Figure 9).

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[16] Norway's first licensing round was announced on 13 April 1965, and 22 production licenses were awarded, covering 78 geographically delimited areas (blocks) – the 1st authors' note.

[17] For more information, see http://www.norskpetroleum.no/en/framework/the-petroleum-act-and-the-licensing-system/

[18] Available on: http://www.npd.no/en/Regulations/Guidelines/

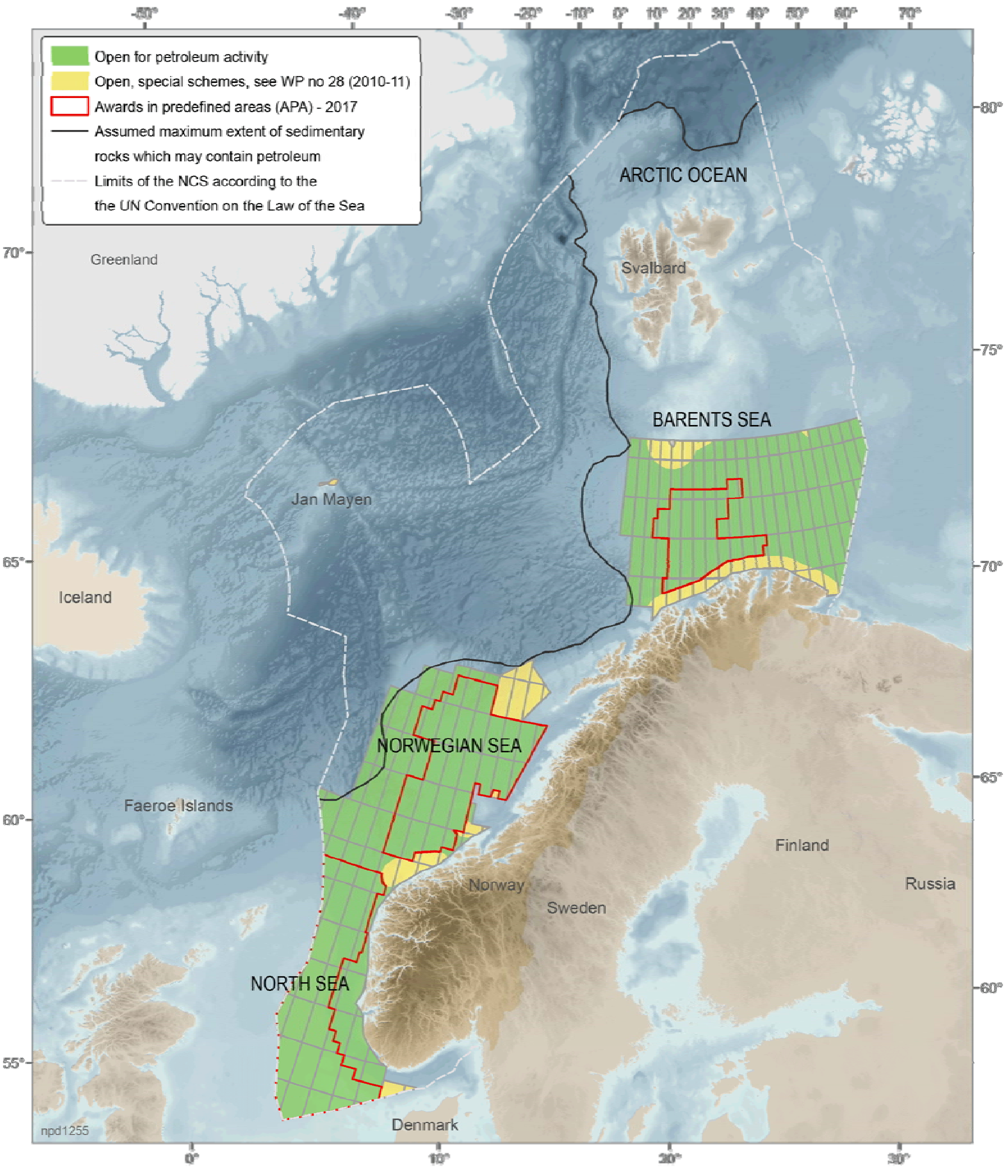

Figure 8. Licensing position for the Norwegian shelf (Source: The Norwegian Petroleum Directorate)

According to Sissel Eriksen, exploration director: *"The Norwegian Petroleum Directorate's analyses show that the greatest undiscovered resource potential on the Norwegian shelf is in the Barents Sea. It is therefore important to facilitate acreage for petroleum activities in this sea area".*

"The interest there is substantial, which is reflected by the fact that 2017 will be a record-year with regard to exploration wells drilled in the Barents Sea. Several of these will also be significant for the blocks now being announced in the 24th round," says Sissel Eriksen[19].

[19] Available on: http://www.npd.no/en/Licensing-rounds/Licensing-rounds/24th-Licencing-round/Announcement/

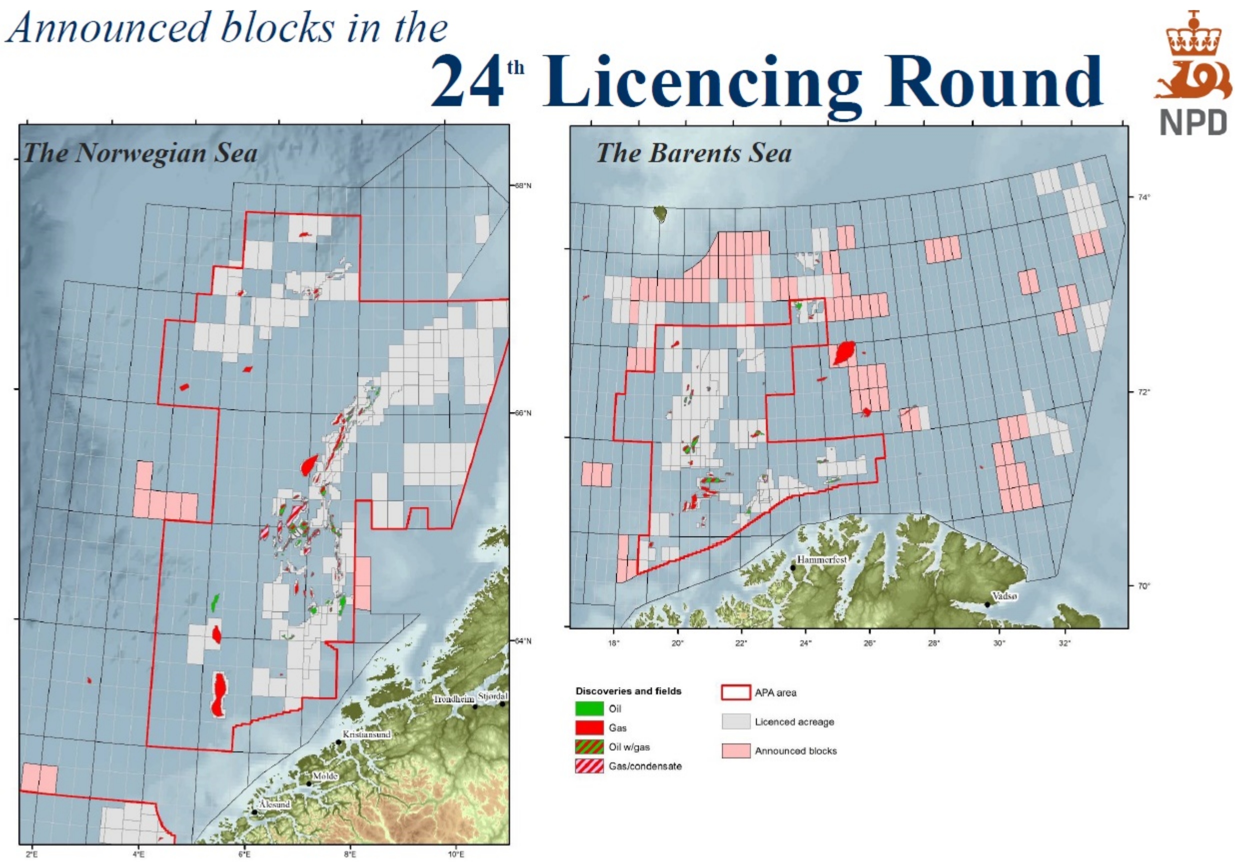

Figure 9. Announced blocks in the 24th licensing round (Source: The Norwegian Petroleum Directorate).

The Norwegian Government aims to award new production licenses in the first half of 2018[20].

02 May 2017 the Ministry of Petroleum and Energy announced the APA 2017, comprising predefined areas with blocks in the North Sea, the Norwegian Sea and the Barents Sea (See Figure 10).

The predefined areas (APA acreage) have been expanded with 34 blocks in the Norwegian Sea and 53 blocks in the Barents Sea since APA 2016.

It is worth adding that the process of assessment ensures that all relevant arguments for and against the project are known before a decision on development is taken.

[20] For more information, see http://www.npd.no/en/Licensing-rounds/Licensing-rounds/24th-Licencing-round/Announcement/

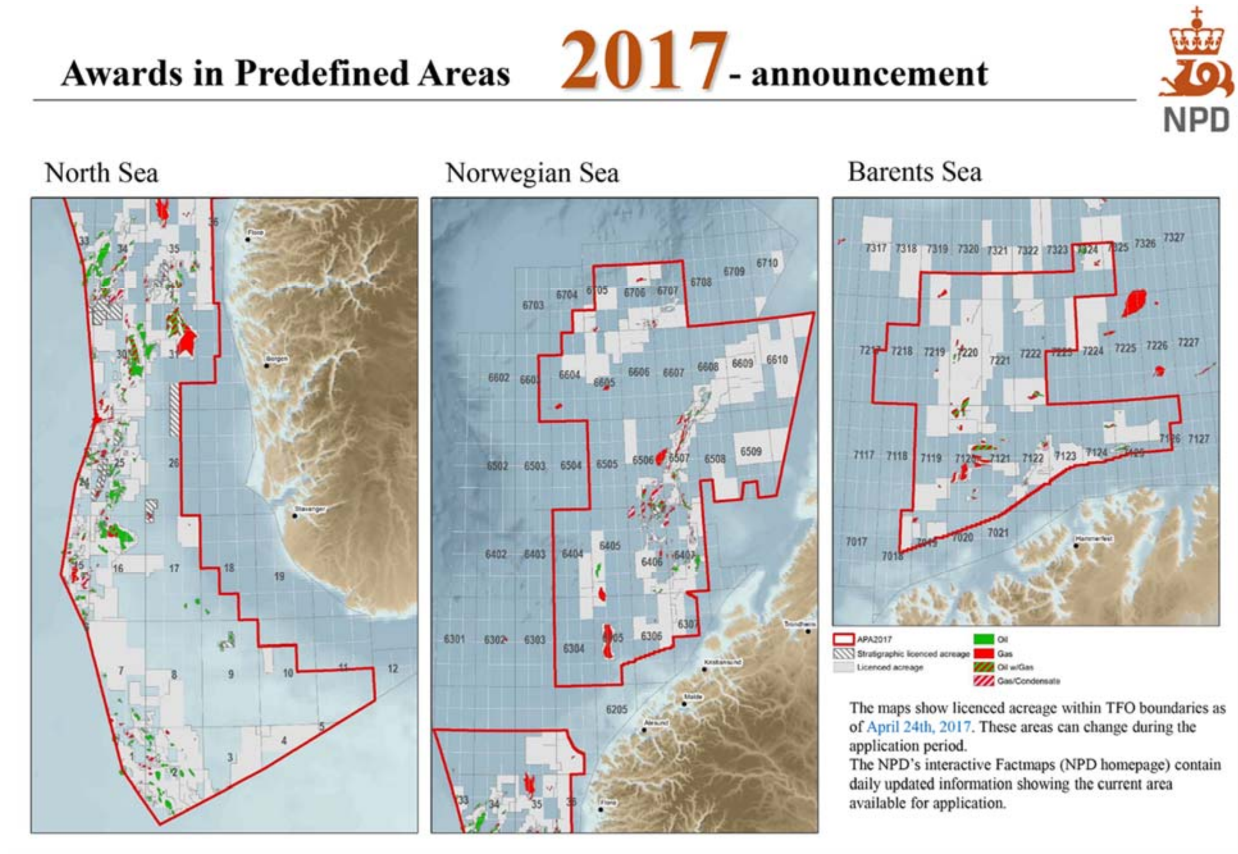

Figure 10. APA 2017 (Source: The Norwegian Petroleum Directorate).

2.3.3. Norwegian non-state institutions and their instruments.

<u>NOFO - The Norwegian Clean Seas Association for Operating Companies[21]:</u>

NOFO was established in 1978. Its strategic goal is "To ensure that oil recovery preparedness is always dimensioned in keeping with the needs and contingency plans of the operating companies". NOFO conducts around 100 exercises each year. Two to three times a year, NOFO conducts exercises that involve several hundred people and 30-50 vessels. These exercises involve the entire organization and are intended to prepare every single participant by simulating realistic scenarios.

According to the interviewee of Norwegian oil company #1: *"Our company is a part of the NOFO cooperation initiative. Together with the NOFO, we develop both the oil recovery system and personnel operating system for a concrete project. Equinor as an operator is responsible for the implementation, and the NOFO is just a tool for the operator. The oil company provides resources, and the NOFO prepares a plan for oil recovery operations. In Equinor, we have a general requirement that the first oil recovery system should be at sea within 5 hours. However,*

[21] In Norwegian, the NOFO means Norsk Oljevernforening For Operatørselskap.

during drilling operations at the Korpfjell in August 2017 the NOFO requirement was different that the whole oil recovery system must be at sea within 2 hours to start the emergency operation".

NOFO serves as a coordinating organization if a spill occurs and is responsible for the tactical and operational management of recovery resources in use.

NOFO's bases and depots contributes to an effective preparedness and mobilization of equipment and vessels.

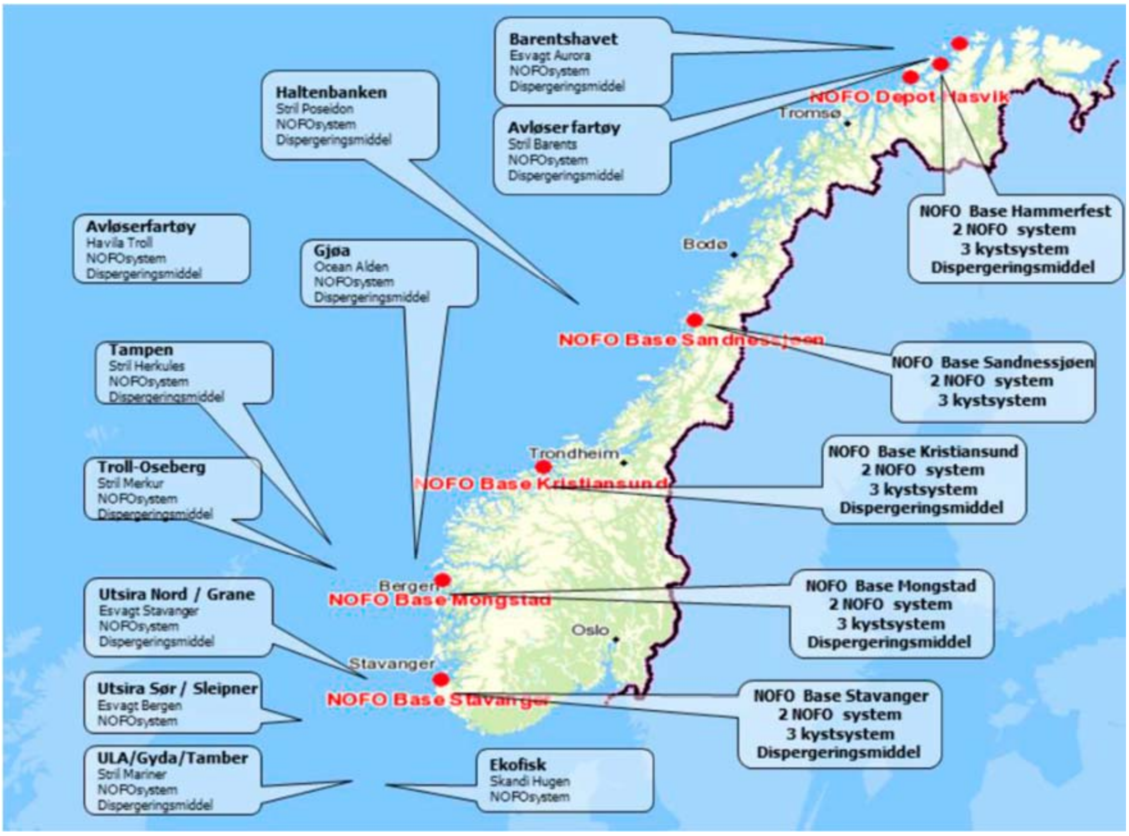

Figure 11. The NOFO bases (Source: NOFO).

<u>Requirements for oil recovery vessels on the Norwegian Continental Shelf (NOFO2009):</u>

The NOFO Standards (the 2009 revision) were developed by the Norwegian petroleum and shipping industry in order to ensure satisfactory safety and efficiency in oil spill response operations on the Norwegian Continental Shelf.

These special standards are intended for the vessels taking part in oil recovery operations and include the requirements for tank heating and ventilation, discharge and loading systems, deck layout for oil recovery equipment and towing boom systems.

Vessels contracted after 01 May 2009 must follow this standard NOFO 2009. The vessel must be ready for oil recovery operations (ORO) with 2 hours of the ORO tanks being loaded and, if necessary, cleaned[22].

The Norwegian Shipowners' Association (NSA):

NSA is a trade and employment organization for Norwegian controlled companies within the shipping and offshore industry. The primary fields are national and international industry policies, employer issues, competence and recruitment, environmental issues and innovation in addition to safety at sea. NSA's members employ over 55,000 seafarers and offshore workers from more than 50 different nations. The members operate within the following sectors:

- Deep sea; Offshore contractors, Offshore services, Short sea, Subsea contractors.

The NSA's primary fields are national and international industry policies, employer issues, competence and recruitment, environmental issues and innovation in addition to safety at sea. The operations of the NSA are executed in close relation to the industry[23].

The Norwegian Oil and Gas Association (Norsk olje og gass, NOROG):

The Norwegian Oil and Gas Association (Norwegian Oil and Gas) is a professional body and employer's association for oil and supplier companies engaged in the field of exploration and production of oil and gas on the Norwegian Continental Shelf. The Norwegian Oil and Gas Association works to solve common challenges for the members and to strengthen the competitiveness of the Shelf.

The vision is "to further develop a competitive oil and gas industry which enjoys respect and trust".

The Norwegian Oil and Gas Association believes that value creation and prosperity are closely linked. Issues pursued by the Norwegian Oil and Gas Association will also be in the best interests of the wider community. The Norwegian Oil and Gas Association's work is based on the following principles and values:

• Respect for people, safety and the environment
• The importance of profitability for the industry
• The principle of free competition
• A high ethical standard and awareness of the industry's social responsibility

[22] For more information, see http://www.nofo.no/globalassets/pdfs/operativ-organisering/nofo-standard-2009---engelsk-versjon.pdf
[23] For more information, see https://www.rederi.no/en/

HSE Regulation in the offshore petroleum activities:

Norway's petroleum sector believes in maintaining a high level of health, safety and the environment (HSE) when developing and operating fields on the Norwegian continental shelf, particularly in the High North, presenting technical and environmental challenges. The HSE regulation contributes to enhancing value creation on the NCS. The Norwegian Oil and Gas Association management's job is to lead and coordinate joint projects on HSE and operations.

A special working party appointed by the OLF has pursued offshore issues in the High North. Its membership has been broadly representative of operator companies, the supplies industry and unions. This working party has devoted particular attention to the additional requirements for thermal protection imposed by colder air and sea climates in the High North. These include training, dress, enclosure of work areas and survival suits. Long transport distances and a lower density of air and sea traffic make bigger demands on emergency preparedness.

The HSE regulations consist largely of risk- and performance-based requirements, as well as risk reduction principles. They regulate important aspects of HSE for the offshore petroleum industry in an integrated and coherent manner.

In addition, they contain helicopter safety guidelines. The helicopter companies operate on fixed routes to and from the offshore installations. These routes are planned in collaboration with the oil companies. Having a fixed flight schedule permits long-term planning of helicopter maintenance and pilot rosters. Day-to-day activities are run by the helicopter companies through their operations centers, which coordinate flights with the oil companies' own operation centers and with Avinor, the state-owned air traffic services provider.

NOFO and the Norwegian Coastal Administration have developed the "HSE Manual – Oil Spill Response", the object of which is to inform all oil spill response personnel about health, safety and environment work in oil spill response operations. The manual has been based on experiences from various oil spills and from a larger number of oil spill response exercises.

Norwegian Oil and Gas Recommended guidelines for safety and emergency preparedness training:

The objective of these guidelines is to establish a joint understanding and practice regarding safety and emergency preparedness training among the players on the Norwegian continental shelf. These guidelines encompass personnel on fixed and mobile facilities, as well as vessels used in the petroleum activities.

Norwegian Oil and Gas' Drilling Managers Forum (DMF):

In 2010 an initiative was taken for joint efforts by Norwegian Oil and Gas and the NSA (Norwegian Shipowners Association). A task force was established with focus on reducing well incidents. One of the recommendations from the task force is to communicate actual well control incidents that have recently occurred on the NCS that lessons are shared and understood. A number of case histories has now been circulated to all installations.

The key message is to focus on what can be learnt from such events. It is hoped that sharing of such incidents will be helpful in our efforts to avoid or reduce the likelihood and severity of well incidents[24].

Barents Sea Exploration Collaboration (BaSEC):

BaSEC was established by Equinor, Eni Norge, Engie (GDF Suez), Lundin and OMV, in April 2015. From summer 2015 all operators on the Norwegian Continental Shelf were invited to join the collaboration.

The following 18 operators are members of BaSEC now:

- Equinor ASA; Eni Norge AS; Lundin Norway AS, OMV Norge AS; Engie (GDF Suez E&P Norway AS); Chevron Norge AS; Repsol Exploration Norge AS; Total E&P Norge AS; Aker BP; ConocoPhillips Skandinavia AS; Wintershall Norge AS; Edison Norge AS; Norske Shell AS; DEA E&P Norge AS; Centrica E&P Norway; Cairn Energy PLC; PGNiG Upstream International; Lukoil Overseas North Shelf AS.

Building on existing knowledge and experience, the cooperation is motivated by the goal of high and cost effective HSE standards for exploration activity in the Norwegian Barents Sea, focusing on new areas opened for oil and gas activity in the 23rd concession round.

The companies aim to develop common solutions that can facilitate:

- A joint operator approach to HSE in the Norwegian Barents Sea;
- Appropriate level of safety and emergency preparedness;
- Data sharing;
- Standardization.

The BaSEC cooperation includes 5 working groups with the focus on the following areas:

- Metocean and ice;
- Environment and oil spill preparedness;

[24] For more information, see https://www.norskoljeoggass.no/en/Activities/HSE-and-operation/Sharing-to-be-better/

- Emergency Response & Logistics: 1) agree on an operator joint approach for establishing an adequate and cost-efficient level of emergency response for remote operations in the Barents Sea; 2) identify potential for cost savings by optimizing logistical solutions and sharing of resources;
- Health and Work Environment;
- Mobile Drilling Units.

The groups ensure that knowledge and experiences are communicated across the member companies and thereby ensure everyone has the full overview. The groups also identify new challenges and propose/execute studies in order to improve the knowledge base and improve operations support tools[25].

DNV-GL

DNV GL (Det Norske Veritas) is an international accredited registrar and classification society. It provides classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas, power and renewables industries. It provides services for 13,175 vessels and mobile offshore units (MOUs) amounting to 265.4 mill gt, which represents a global market share of 21%[26]. DNV's motto is "It is time to take a broader view to address increased complexity".

2.3.4. Taxation policy

The petroleum taxation system is based on the rules for ordinary company taxation and are set out in the Petroleum Taxation Act (Act of 13 June 1975 No. 35 relating to the taxation of subsea petroleum deposits, etc.).

The Norwegian Oil and Gas Taxation Code includes direct and indirect taxation. Because of the extraordinary returns on production of petroleum resources, the oil companies are subject to an additional special tax. In 2017, the ordinary company tax rate is 24 %, and the special tax rate is 54 %. In 2018, these tax rates will be adjusted to 23 % and 55% respectively. This gives a marginal tax rate of 78 %. Thus, direct taxes consist of ordinary petroleum tax and special tax.

In 2017, Norway's estimated tax revenues from petroleum activities are about NOK 72 billion (2018).

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[25] For more information, see https://www.norskoljeoggass.no/Faktasider/Miljo1/Barents-Sea-Exploration-Collaboration/

[26] Available on: http://www.tankeroperator.com/news/dnv-gl-to-unveil-rules-this-year/6356.aspx

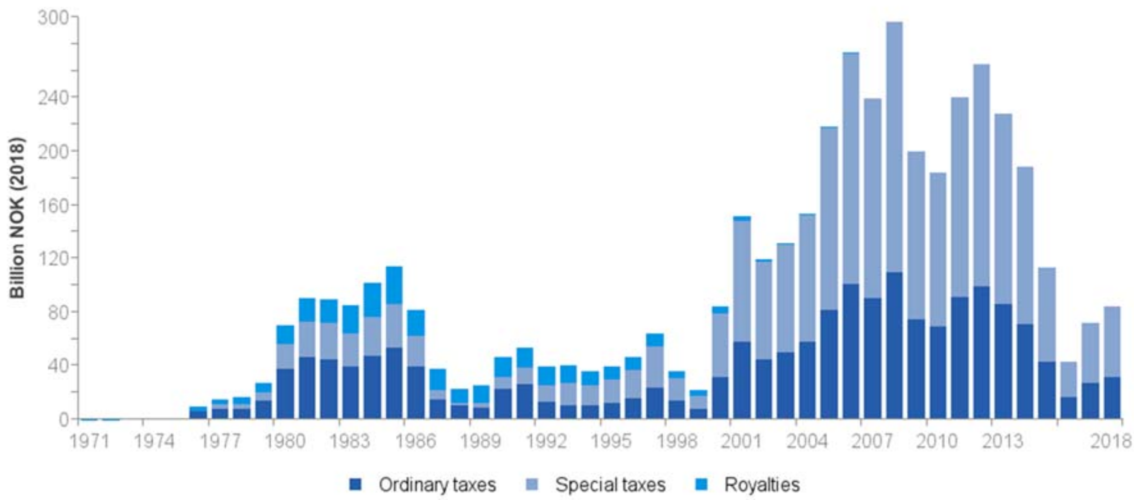

Figure 12. The net government cash flow from petroleum activities, 1971-2018; updated on 12.10.2017 (Source: Ministry of Finance, Statistics Norway)

Indirect taxes include carbon dioxide taxes and nitrogen oxide tax. VAT (the value added tax), which generally is the main indirect tax in Norway at a rate of 25%, plays a limited role for companies engaged in exploration/production on the NCS. The supply of certain goods and services to specialized ships for use in the offshore petroleum activities is zero-rated. The supply of certain goods and services for use outside Norwegian territorial waters - the 12 nautical mile zone - for use in offshore petroleum activity to licensee companies, drilling companies and the owners/hirers of platforms are zero-rated[27].

Sale of crude oil and gas made by licensees will in practice always be zero-rated. Import of goods into Norway's customs zone are generally subject to import Vat. The customs zone consists of the mainland and 12 nautical miles outside the mainland. Therefore, goods that are provided to e.g. installations outside the Norwegian customs zone are not subject to the import VAT. If goods are placed in a customs warehouse, in transit or temporarily imported into Norway, import VAT may also be avoided[28].

The petroleum taxation system is intended to be neutral, so that an investment project that is profitable for an investor before tax is also profitable after tax. This ensures substantial revenues for Norwegian society and at the same time encourages companies to carry out all profitable projects. To ensure a neutral tax system, only the company's net profit is taxable, and losses may

[27] For more information, see https://www.skatteetaten.no/en/International-pages/Felles-innhold-benyttes-i-flere-malgrupper/Articles/Special-rules-for-goodsservices-for-use-in-offshore-petroleum-activity/

[28] Available on: https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/gx-er-oil-and-gas-taxguide-norway.pdf

be carried forward with interests. Neutral properties in the tax system is also important when defining investment-based tax deductions.

2.4. Regulatory framework in Russia

Russia possesses a strong sense of being an Arctic nation. Accordingly, it has developed extensive, strict legal criteria for the impact of many areas of offshore oil and gas activity.

Russian national regulations include the set of laws, federal programs and strategies concerning the Russian continental shelf and field operations, the tax regime, use of subsurface resources, licenses and permits, environmental regulations, procurement requirements, labor standards and social protection.

2.4.1. The main federal programs

The Energy Strategy of Russia up to 2030:

The official Government policy objectives are set out in the Energy Strategy of Russia up to 2030:

- Transition to innovative development and energy efficiency;
- Transforming the structure and scale of energy resource production;
- Creating a competitive market in the energy sector;
- Further integration into the global energy system.

The Principles of the State Policy of the Russian Federation in the Arctic for the period up to 2020 and beyond:

They were adopted in 2008. The principles define the main goals, key objectives, strategic priorities and mechanisms for the implementation of the state policy in the Russian Arctic. It also determines the system of measures for strategic forecasting and planning of socio-economic development of the Arctic zone and the national security of Russia.

The Strategy for the Development of the Arctic Zone of the Russian Federation:

It was adopted in 2013 and emphasizes improving geological prospection of the continental shelf, implementing large-scale resource projects as well as upgrading infrastructure related to transport and resource development.

2.4.2. General Russian legal framework on the continental shelf

Federal Law #187-FZ on the Continental Shelf of the Russian Federation of 25 October 1995[29]:

This Federal Law defines the status of the continental shelf of the Russian Federation, the sovereign rights and jurisdiction of the Russian Federation over its continental shelf and their exercise in accordance with the Constitution of the Russian Federation, the generally recognized principles and rules of international law and the international treaties of the Russian Federation.

According to this Law, "the continental shelf of the Russian Federation comprises the seabed and subsoil of the submarine areas situated beyond the territorial sea of the Russian Federation throughout the natural prolongation of its land territory to the outer edge of the continental margin" (Article #1).

The continental margin is the prolongation of the land mass of the Russian Federation and consists of the seabed and subsoil of the shelf, the slope and the rise.

In accordance with the provisions of article 2 of this Federal Law, the outer edge of the continental shelf is situated at a distance of 200 nautical miles from the baselines from which the width of the territorial sea is measured, provided that the outer edge of the continental margin does not extend for a distance of more than 200 nautical miles.

Federal Law No. 2395-1 "On Subsoil" of 21 February 1992 (as amended 30 September 2017):

This Law governs the relations arising in the field of geological studying, use and protection of subsoil, use of waste of mining and the related processing industries, specific mineral resources (brine of estuaries and lakes, peat, sapropel and others), underground waters, including passing waters (the water extracted from subsoil together with hydrocarbon raw materials), and the waters used by subsoil users for own production and technological needs.

This Law contains legal and economic basis of complex rational use and protection of subsoil, provides protection of interests of the state and citizens of the Russian Federation, and also the rights of subsoil users.

Article 1.2. of the Subsoil Law stipulates that subsoil within the territory of the Russian Federation, including the subsoil domain and mineral resources contained therein, energy and other resources, shall be state property. The basis of the mechanism for realizing the right of state

[29] Available on: http://www.un.org/Depts/los/LEGISLATIONANDTREATIES/PDFFILES/RUS_1995_Law.pdf

ownership of subsoil is the principle of the chargeability of subsoil use, which is a special legal tool based on the principle of rental relations.

Federal Law No. 225-FZ "On Production Sharing Agreements" of 30 December 1995:

The Law governs the use of subsoil and investment activities, establishes a legal basis for relationship arising with respect to Russian and foreign investment in exploration, development and production of mineral raw materials within the territory of the Russian Federation, as well as on the continental shelf and/or within the boundaries of the exclusive economic zone of the Russian Federation under the terms and conditions of production sharing agreements.

Clause 7 of the Law states the limitation of foreign employees and subcontractor's involvement:

- Russian entities have prerogative right to participate in a project as subcontractors;
- Cost of domestic materials and equipment should be no less than 70% of total costs for materials and equipment in a year. Items are considered as domestic, if they are produced by Russian entities or individuals at Russian territory with Russian materials and details (no less than 50%)[30].

Federal Law No. 155 - FZ "On internal waters, territorial sea and contiguous zone" of 31 July 1998 (as amended 22 December 2014):

The Law establishes status and legal foundations of internal waters, territorial sea and contiguous zone of the Russian Federation, including the rights of the Russian Federation within its internal waters, territorial sea and contiguous zone and the modalities of their application in accordance the Russian Constitution, universally recognized principles and norms of international law and international agreements of the Russian Federation and Federal Laws.

Federal Law No. 147-FZ "On Natural Monopolies" of 17 August 1995 (amended 08 November 2007)[31]:

The Law stipulates that transportation of natural gas via pipelines, as well as transportation of oil and products of oil refining via trunk pipelines are covered by natural monopolies. In addition, this Law regulates services of transportation terminals, ports and airports.

[30] Available on https://www.wto.org/english/thewto_e/acc_e/rus_e/WTACCRUS48_LEG_76.pdf
[31] Available on: https://www.wto.org/english/thewto_e/acc_e/rus_e/WTACCRUS58_LEG_52.pdf

2.4.3. The licensing system and foreign investment agreements

In the Russian Federation, there are also two legal approaches to natural gas production: the licensing approach (licenses are awarded by tenders and competitions) and production sharing agreements. This model can provide a real inflow of investments, despite existing issues of inflation, the lack of an effective tax system, and political and legal instability. However, subsoil areas according to the production sharing agreement are not currently distributed.

The licensing regime:

The licensing regime is administered by the Ministry of Natural Resources and Ecology of the Russian Federation and federal agencies under its jurisdiction. Subordinate to that Ministry, the Federal Agency for Subsoil Use (Rosnedra) is the administrative agency primarily responsible for the regulation of oil and gas extraction. Rosnedra is responsible for:

- Issuing, suspending and revoking subsoil use licenses;
- Approving deposit development plans;
- Transferring and storing geological information.

The Federal Service for Supervision of Nature Use (Rosprirodnadzor) oversees compliance with legislation regulating subsoil use and protection of the environment. Additionally, the Federal Environmental, Industrial and Nuclear Supervision Service (Rostekhnadzor) issues mining allotments that determine deposit boundaries, safety certificates and operating licenses.

There should be no more than one Operator at a new hydrocarbon deposit. License holder are resource developers, which have to follow some restrictions:

- Resource developers must have operated on the Russian continental shelf for at least 5 years;
- Resource developers must be companies in which the government holds more than 50% of voting shares, either directly or indirectly, i.e. resource developers may not be private Russian or foreign companies, including those having significant offshore experience (according to Federal Law "On Subsoil", Clause 3 of Article 9).

At the moment only two companies meet these requirements: "Gazprom" PJSC; "Rosneft oil company", PJSC; Zarubezhneft" JSC.

As commented on state control and licensing by Head of Rosneft, Igor Sechin, in a Bloomberg News interview:

"*The type of ownership isn't a key factor, the company's efficiency on the market is. And in the case of our company, the presence of the state as a controlling shareholder allows us to get* *licenses to work on the shelf without lots of competition. Because only Gazprom and Rosneft, according to Russian law, have an opportunity to work on the shelf. I think for our shareholders this is a blessing."*[32]

These requirements are not applicable to both offshore projects: Sakhalin-1 and Sakhalin-2 under terms of PSAs, concluded before the requirements came into force in 2008.

<u>Foreign investment agreements.</u>

The governance of major oil and gas projects is framed within investment agreements of various types, which are negotiated between investors and host states. Investment agreements typically address issues such as the applicable regulatory regime, environmental standards and liabilities.

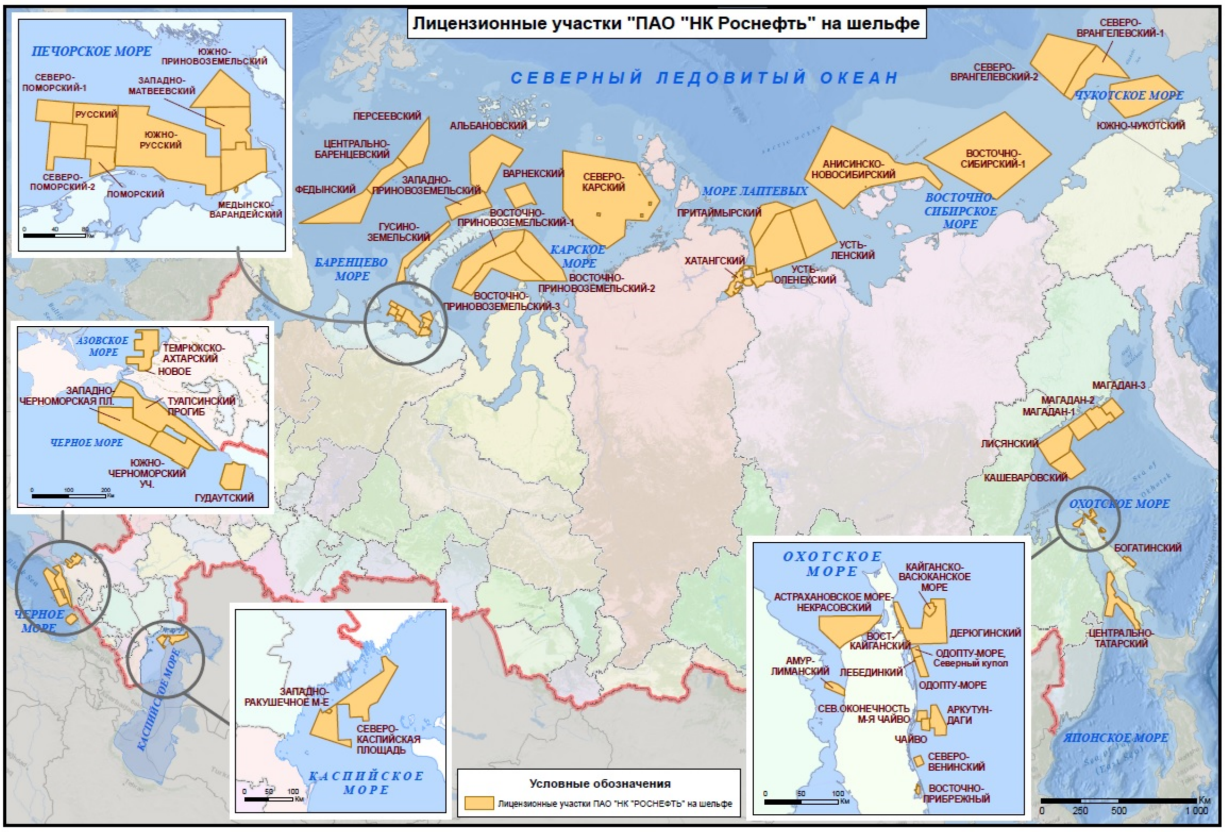

Figure 13. Offshore licenses issued on the Russian continental shelf (Source: Rosneft).

[32] Available on: https://www.rosneft.com/press/Rosneft_in_the_Media/item/173830/

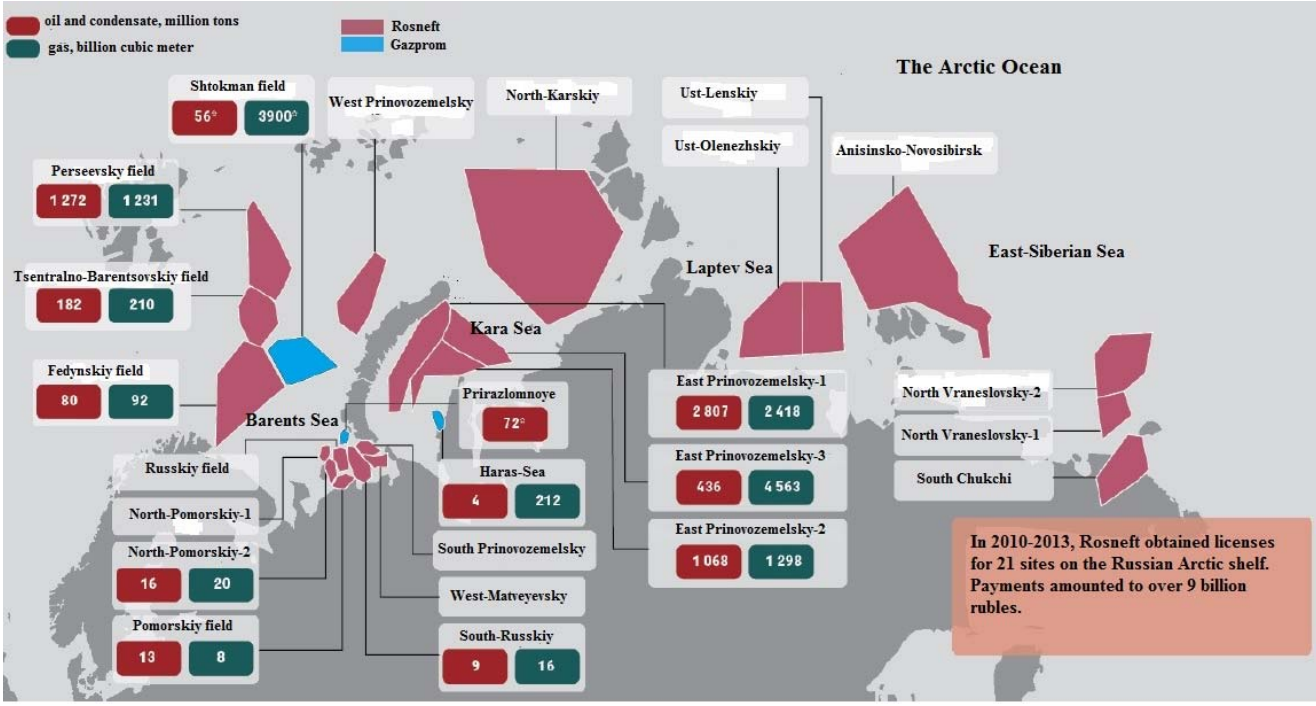

Figure 14. License areas of Rosneft and Gazprom in the Russian Arctic (Source: Rosneft)

Production sharing agreements

In the post-Soviet period (the early 1990s), international oil and gas investment projects were negotiated in the form of production sharing agreements (PSA), because companies faced greater investment risk.

"Production sharing agreement" means an agreement under which the Russian Federation grants an investor free of charge and for a definite period of time exclusive prospecting, exploration and production rights on mineral resources within the subsoil limits specified in the Agreement, and rights to perform related works, while the investor undertakes to perform the activities at its own expense and risk. Under a PSA the operator bears the cost of development, which it then recoups through its allocated share of production[33].

The Russian government abandoned the PSA format in 2008, when the tax policy was adjusted, and currency exchange rates stabilized[34].

[33] There are agreements of various types within oil & gas industry: in terms of concession agreements (e.g. Brazil, Egypt, Nigeria, Oman, Thailand), the lease of subsoil plots (e.g. the USA, Canada), or production sharing agreements (e.g. Angola, Cameroon, China, Denmark, Uganda, Vietnam, the Netherlands, the Philippines).

[34] First, since 2003, the Russian legislation was tightened with respect to PSA in order to reduce the number of oil and gas fields eligible for development under PSAs and the federal tax code was also adjusted to make future PSAs less attractive to foreign investors. Secondly, since 2008, the new requirements on licence holder were put into force in Law "On Subsoil"), which abandoned PSAs application (the author's note).

At this moment, in Russia there are only three ongoing production sharing agreements concluded before these mentioned above requirements came into force. The development of two offshore fields: Sakhalin-1 (Exxon Neftegas Limited as an operator) and Sakhalin-2 (Sakhalin Energy as an operator) has been carried out under two production sharing agreements[35].

Foreign investment agreements may stipulate that a project is to incorporate a certain amount of local content (e.g. a minimum proportion of materials or labor, or a minimum value of contracts). For example, the Sakhalin-2 project PSA requires that 70% of materials and labor be of Russian origin, provided they can meet equivalent prices and quality to foreign alternatives. Since 1996, theSakhalin-2 project has sourced 91% of its materials and equipment within Russia (10.2 million tons) and has awarded contracts to the value of 10.9 billion USD (the total amount is 20 billion USD)[36].

PSA are important to be applied in cases of:

- Technology difficulties: special technologies are need for efficient special technologies are needed for efficient development of a field. Russian companies haven't access to these technologies or want to avoid them. PSA allows to attract those who can and are willing to overcome such difficulties;
- Low profitability: development of marginal deposits under licensing is not interesting for investors. For such deposits, PSA plays a role of "a bridge into profitability".

In Russia, the national legal regime is executed in relation to foreign investors according to the general rule. However, specific limitations were set by the following regulations:

- Federal Law No.57-FZ "Foreign Investments in the Business Entities of Strategic Importance for National Defense and State Security", dated April 29, 2008;
- Federal Law No.58-FZ "Introducing Amendments to Certain Legislative Acts of the Russian Federation and Abolition of Certain Provisions of Legislative Acts of the Russian Federation in connection with the adoption of the Federal Act, Foreign Investments in the Business Entities of Strategic Importance for National Defense and State Security Act".

Both laws deal with restrictions applied to companies engaged in geological exploration and/or mineral prospecting and production in subsoil areas of federal significance.

[35] The 3d production sharing agreement concerns the onshore Khariaga project in the Nenets Autonomous Region.
[36] Available on http://www.sakhalinenergy.com/en/ataglance.asp?

2.4.4. Taxation policy

<u>Main tax regulatory framework:</u>

1. Introduction of Mineral Extraction Tax / Oil and Gas Condensate

Federal Law No. 263-FZ "Concerning the Introduction of Amendments to Chapter 26 of Part Two of the Tax Code and Article 3.1 of the Federal Law "Concerning Customs Tariff" of 01 January 2004:

The Law changes the base rates of mineral extraction tax in the case of the extraction of oil and gas condensate. The amendments introduced to the Law of the Russian Federation "Concerning the Customs Tariff" provide for a gradual reduction of the rates of export customs duties on crude oil.

2. Stimulation of Hydrocarbon Production

Federal Law No. 268-FZ "Concerning the Introduction of Amendments to Parts One and Two of the Tax Code of the Russian Federation and Certain Legislative Acts of the Russian Federation in Connection with the Implementation of Measures to Provide Tax and Customs Tariff Incentives for Hydrocarbon Extraction Activities on the Continental Shelf of the Russian Federation" of 01 January 2014:

The Law was designed to encourage investment in new offshore hydrocarbon deposits. In particular, organizations which carry out hydrocarbon extraction activities at such deposits are granted tax and customs- tariff privileges, by creating a special tax regime for continental shelf hydrocarbon production projects.

<u>Tax regime:</u>

Oil and gas revenues account for approximately 36% of federal budget revenue.

The chargeability of subsoil use is a special legal instrument (Section V "Subsoil use payment of Federal Law No. 2395-12 "On Subsoil"). The system of subsoil use payments includes three separate types of payments:

- One-off payments for the award of the subsoil license and other instances established in the subsoil use license like changing boundaries of subsoil plots allotted for use (Law No. 2395-15, Article 40);
- Participation fee in a tender or auction (Law No. 2395-15, Article 42);
- Regular payments for the use of subsoil, including geological study, exploration and construction of underground facilities (Law No. 2395-15, Article 43).

The Mineral Resource Extraction Tax (MRET) is a specific tax payable by producers. It was introduced in January 1, 2002[37] and replaced three previous subsoil use payments: payment for subsoil use (royalties), fees for the regeneration of mineral resources and raw materials, and excises on oil and gas condensate. MRET is calculated based on the physical volume of oil and gas extracted:

- Oil extraction tax – based on fluctuations in the world oil price, as well as the depletion and volume of reserves. In 2017, it is currently 919 RUB per ton;
- Gas extraction tax – based on the rate of 35 RUB per 1,000 cubic meters, which is multiplied by a number of coefficients expressing the complexity of the gas and the cost of transportation. For gas condensate, the rate is 42 RUB per ton.

Some key legislative changes were done to Arctic offshore projects:

- Companies performing exploration activities on the continental shelf can recognize R&D costs at a rate of 1.5;
- The 0% VAT rate for the services related to carriage and transportation of hydrocarbons produced on the continental shelf abroad;
- VAT on the acquisition of services to minerals exploration and production on the continental shelf may be recovered from the RF budget only if the service recipient is an RF tax resident.

<u>Tax breaks for the Russian Arctic projects:</u>

In 2012, Russian Prime Minister Dmitry Medvedev noted that Russian oil and gas operators' attempts to explore the northern sea shelf were proceeding rather slowly. Exploration work in the Russian section of the Arctic has been 10 times less extensive than in the US section of the Chukchi Sea and 20 times less than in the Norwegian Arctic shelf. The Russian government reportedly decided to accede to the requests of major state-controlled oil and gas operators to amend the federal tax code in order to generate additional funding for exploration of crude oil and natural gas deposits on the northern sea shelf. On the other hand, many of oil and gas projects have been the subject of lobbying to improve primarily fiscal terms for long-term development.

Here we consider only several examples of tax breaks as a government support to the Russian arctic projects.

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[37] See: Federal Law as of August 8, 2001 No. 126-FZ "On Amendments and Additions to Part Two of the Tax Code of the Russian Federation and Certain Other Acts of the Legislation of the Russian Federation, and on the Repeal of Certain Acts of the Legislation of the Russian Federation" Collection of legislation of the Russian Federation. 2001. No. 33 (part 1). Art. 2174.

- *Prirazlomnaya platform project:*

Since 2003, the Prirazlomnoya platform project has been the subject of lobbying to improve fiscal terms. In 2012, it received a reduced export duty at "around" 50 % of the normal rate. Other sources put the export duty at 45% of the underlying rate[38].

According to the official budget plans for 2014-2015, the Prirazlomnoye project was taxed at a level of US $155.3 per tons compared to US $348 per ton, implying an effective rate of 44.6 %. However, in April 2014 the rate was increased to US $190.8 per tons compared to US $387 per ton, which implied a rate of 49.3 %. These figures show that the export duty for the Prirazlomnaya platform has changed and not proportionally.

After extensive lobbying campaign, in September 2013, the Prirazlomnaya platform was included in Category 2 of Federal Law 268-FZ and granted 7 years of 0 mineral extraction tax for up to 35 million tonnes of oil starting from January 01, 2015.

In addition, the Prirazlomnaya platform project has been exempted from property taxes, normally levied at 2.2 % of "the yearly value of the object". As a result, the regional budge has run a deficit of 30%[39].

The government support to the Prirazlomnaya platform project has been provided by the following legislative acts:

1. Federal tax breaks:

- Federal Law 268-FZ, September 30, 2013: mineral extraction tax: 0 ruble per ton for up to 35 mmt within 7 years from January 01, 2015;
- Federal Law 268-FZ, September 30, 2013: exemption from property tax of 2.2%;
- Government Instructions on Export duties: the level of export duties is lower than normal rates.

2. Federal legislation on accelerated depreciation based on Tax Code of the Russian Federation (Articles 258-259.3):

- Immediate depreciation allowance for up to 30% for fixed assets;
- Accelerating depreciation schedule (up to twice as fast) for fixed assets employed in an aggressive environment (e.g., north conditions of the Arctic Circle).

Actually, it is worth noting that the tax breaks in case of the Prirazlomnaya platform were granted after most of the investments had already been made (Lunden and Fjaertoft, 2014).

[38] For more information, see https://www.vedomosti.ru/business/articles/2012/06/18/gazprom_nakonec_poluchil_lgoty_dlya_prirazlomnogo

[39] For more information, see http://narianmar.bezformata.ru/listnews/byudzhet-2014-budet-defitcitnim/14950437/

• *Agreement between Rosneft and ENI on the development of the Fedynskiy field in the Barents Sea:*

The key factor that prompted Rosneft and ENI to sign the agreement on the mutual Fedynskiy field development in 2012 was the steps taken by the Government of the Russian Federation to introduce tax incentives for offshore production, including cancelling export duties and introducing a reduced Mineral Extraction Tax rate of 5-15% depending on project complexity. The government also offered guarantees that the favorable tax regime will remain in place for a prolonged period[40].

The main reason for Rosneft's request for tax breaks was high costs. In the exploration phase of the Fedynskiy field, Eni will fund up to US $1.4 billion; it will also cover Rosneft's previous expenditures in the area. However, in the development phase, Rosneft will be responsible for covering 66.7% of costs, while ENI will carry 33.3%. Since the total cost of exploring and developing the Fedynskiy field is anticipated to reach US$50-70 billion, Rosneft requested the government support.

2.4.5. Northern Sea Route regulations

Offshore logistics and offshore exploration activities in the Russian Arctic Seas like the Kara Sea, the East-Siberian Sea, the Laptev Sea and the Chukchi Sea are subject to a set of specific, national regulations applied for navigation along the Northern Sea Route (NSR).

The Northern Sea Route is defined by the Russian legislation as *"a historically developed national transport communication of the Russian Federation in the Arctic region"* (Law #155-FZ, 1998). The NSR is not a specific route but a multitude of passageways in the Arctic Ocean, and mostly trafficked along the Russian Arctic coast.

There are two different understandings of what the Northern Sea route is. The international community associates the NSR with the Northeast Passage that is the shipping route connecting Europe and Asia; and it is considered as the potential transit route for international shipping. You can see it as marked by a red line on the two first pictures above. However, the current Russian legislation defines the length of the Northern Sea Route as not covering all the waters of the Russian Arctic – only from Kara Gate towards the Dezhnev Cape in the Bering Strait (See Figure 15).

[40] Available on https://www.rosneft.com/press/releases/item/114471/

Marine transportation on the Northern Sea Route is regulated by the legislation based on the principles of the UNCLOS, in particular Article # 234 “Ice-covered Areas”. Article #234 authorizes the coastal states within the exclusive economic zone to adopt and enforce the non-discriminatory laws and regulations for prevention and monitoring of marine pollution from vessels in the areas covered with ice for most of the year.

The Russian domestic legislation plays also a key role in defining norms and rules for marine activities in the Russian Arctic.

The Marine Doctrine, adopted in 2001, became a key document for the Russian maritime legislation, which governs the national maritime policy until 2020. The doctrine establishes that “maritime transport is crucial in ensuring the domestic traffic, especially in regions, where sea transportation is the only mode of transport, as well as in foreign economic activity”. According to the Maritime Doctrine, the role of maritime transport has been determined as decisive for the maintenance and development of the High North and Far East.

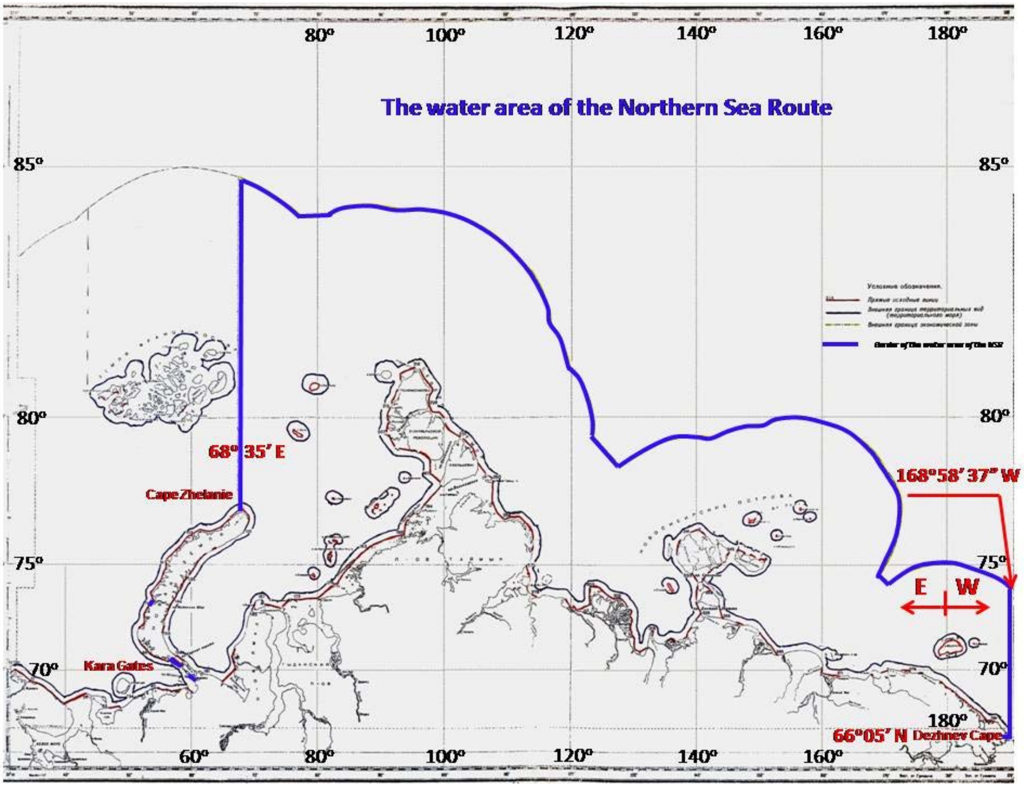

Figure 15. The Northern Sea Route and the Northeast Passage (Source: Russiancouncil.ru)

In 2012, the Russian government adopted new Federal Law No. 132-FZ "On Amendments to Specific Legislative Acts of the Russian Federation related to Governmental Regulation of Merchant Shipping in the Water Area of the Northern Sea Route" of 28 July 2012[41]. This Federal Law No. 132-FZ presented amendments to make changes and determine the certain laws and legislative acts, including the new Rules of Navigation in the water area of the Northern Sea Route, adopted January 17, 2013. The essential articles of the Rules of Navigation include:

- Procedure of the navigation of ships in the water area of the NSR;
- Rules of the icebreaker assistance of ships in the water area of the NSR;
- Rules of the pilot ice assistance of ships in the water area of the NSR;
- Rules on the assistance of ships on seaways of the water area of the NSR;
- Provision about the navigational-hydrographic and hydrometeorological support of the navigation of ships in the water area of the NSR;
- Rules of the radio communication during the navigation of ships in the water area of the NSR;
- Requirements to ships pertaining to the safety of navigation and protection of the marine environment in the water area of the NSR;

[41] Federal Law No. 132-FZ is well-known as the NSR Law (the 1st author's note).

- Other provisions in relation to the organization of the navigation of ships in the water area of the NSR[42].

In addition, the current NSR legislation is carried out through the following norms:

- Basics of the State Policy of the Russian Federation in the Arctic;
- Application for Admission to navigate in the Northern Sea Route Area;
- Communications instructions for Arctic navigation 2012 - 2013 on the Northern Sea Route;
- Permissions for Cabotage Transportation and Towing.

The responsibility for administrating the NSR is vested with the NSR Administration. This organization grants permissions for the navigation of ships in the water area of the NSR. Granting permissions is effectuated on the basis of applications that can be submitted to the NSRA by email up to four months prior to the intended passage and not less than 15 days prior to entry into the NSR. Applications in Russian or in English can be submitted by the shipowner, the shipowner's representative or the ship's Master. The NSR Administration notifies the shipowner within 12 days if permission has been granted or, if not, of the reasons justifying the refusal. The information is also posted the NSR Administration website.

Most vessels entering or transiting the NSR will require icebreaker escort. Information on the necessity to use icebreaker assistance under heavy, medium and light ice conditions while sailing the water area of the NSR is provided by the NSR Administration. Icebreaker assistance is rendered by the icebreakers authorized to navigate under the State flag of the Russian Federation.

Icebreaker assistance involves ice reconnaissance. Icebreakers make channels in ice. The fee rate of the icebreaker assistance is determined by Order of Federal Tariff Service No. 45-T/1 "On approval of the tariff rates for provision of icebreaker pilotage services provided by the FSUE "Atomflot" on the Northern Sea Route water area" of 14 March 2014. This Order takes into account the capacity of the ship, the ice class of the ship, the escorting distance and the period of navigation.

Pilot ice assistance of ships is carried out with the purpose of ensuring navigation safety, the prevention of accidents, as well as the protection of the marine environment in the water area of the NSR. During the pilot ice assistance of ship, the ice pilot gives recommendations to the vessel's master concerning:

[42] For more information, see www.NSRA.ru

- Assessment of ice conditions and possibility of safe navigation for the vessel in the current conditions;

- Choice of the optimal route for the vessel and the appropriate navigation tactic for the vessel on ice-infested water during independent voyage;

- Selection of speed and ways of maneuvering by the vessel to avoid hazardous interaction between the vessel's hull and propeller-rudder system and ice;

- Ways to maintain safe speed and distance to the icebreaker or another vessel ahead while proceeding in an ice caravan;

- Ways to fulfill instructions received from the icebreaker performing icebreaker support.

2.4.6. SAR regulations

The Russian authorities and regulatory framework:

Any emergency response in Russia is organized and performed in the framework of the Integrated National Emergency Prevention and Response System of the Russian Federation (INEPRS), which integrates the state authorities and necessary OSR resources/personnel. INEPRS was established by the Russian Federation Ministry of Transport (Mintrans) via the Federal Agency of Maritime and River Transport (Rosmorrechflot[43]).

Responsibility for the regulatory regime on environmental protection for offshore oil and gas development belongs to:

- The Ministry of Natural Resources and Environment of The Russian Federation (Minprirody of Russia);
- The federal Supervisory Natural Resources Management Services (Rosprirodnadzor);
- The Federal Subsoil Resources Management Agency (Rosnedra);
- The Federal Water Resources Agency (Rosvodresursy);
- The Federal Service on Hydrometeorology and Environmental Monitoring (Roshydromet).

The "Ecological Doctrine of the Russian Federation", worked out by Ministry of Nature Resources and approved in 2002, is the main document defining the state policy of the Russian Federation, its goal, directions, objectives and principles for the long-term period. According to the Ecological Doctrine, the strategic goal of the state ecological policy is preservation of ecosystems, maintenance of their integrity and vital functions for sustainable development of the

[43] The official Russian name (the 1st author's note).

society, improvement of living standards, improvement of public health and the nation's demographics, and maintenance of the country's ecological safety.

<u>Marine Rescue Coordination Centers:</u>

The Federal Agency of Maritime and River Transport (Rosmorrechflot) and the State Marine Pollution Control, Salvage and Rescue Administration of the Russian Federation (Gosmorspassluzhba) are responsible for oil spill preparedness and response at sea from vessels and facilities regardless their ownership or nationality. The Mintrans of Russia is empowered on behalf of the Russian Federation to request assistance from foreign countries or to decide to render requested assistance.

Search and Rescue operations and oil spill response are organized through the Marine Operations Headquarters:

- In the Western sector of the Arctic – on the basis of the Federal State Unitary Enterprise "Atomflot";
- In the Eastern sector of the Arctic – on the basis of "Far Eastern Shipping Company".

7 Marine Rescue Coordination Centre (MRCC) and 6 Marine Rescue Co-ordination Subcenters (MRSCs) are established by Gosmorspassluzhba for the emergency response at sea, including OSR. The following MRCCs and MRSCs currently operate in the Russian sector of the Arctic:

MRCC Murmansk (sector West), MRCC Dixson (sector East), MRSC Arkhangelsk, MRSC Tiksi and MRSC Pevek (See Figures 16 and 17).

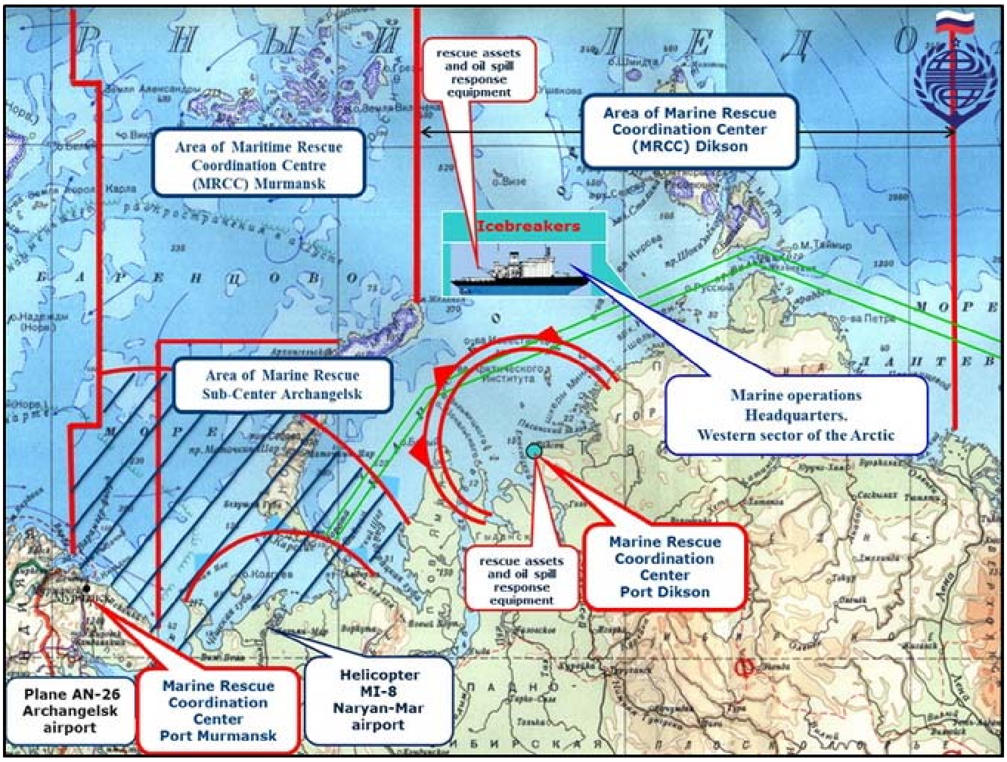

Figure 16. The location of MRCCs and MRSCs in the west part of the Russian Arctic (Source: CHNL)

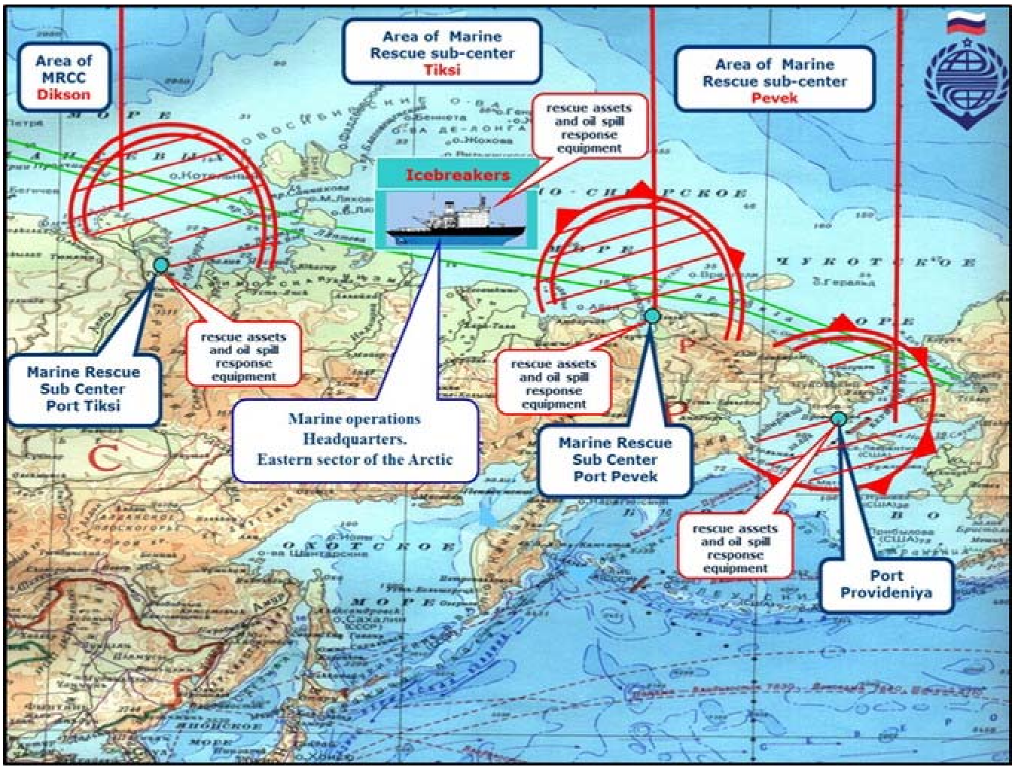

Figure 17. The location of MRCCs and MRSCs in the east part of the Russian Arctic (Source: CHNL).

MRCCs and MRSCs have necessary equipment designed to operate in harsh Arctic conditions and fully comply with the International Convention on Maritime Search and Rescue at Sea, 1979, and the International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual.

Since navigation in the area of MRSC Tiksi and MRSC Pevek is seasonable, these MRSCs operate only during the navigation season (approximately from the mid of July to the end of September).

Taking into account the remoteness of basing points of MRCCs, the basis for search and rescue in the Arctic are icebreakers of FSUE "Atomflot" and "Far Eastern Shipping Company" Ltd, while they are in performance of tasks in the Arctic zone.

In some cases, to search and rescue of people in distress at sea are attracted aviation emergency rescue services of the federal bodies of executive authority (the Ministry of Defense of Russia, the Russian Emergencies Ministry, and the Federal Security Service of Russia).

2.4.7. The sanctions regime

The sanctions against Russian economic sectors, including the oil and gas sector, were introduced by the EU, U.S. and Canada in three rounds:

1) the first round applied to equipment deliveries and took effect in late July – early August 2014;
2) the second round was introduced in September 2014. It extended the scope of the sanctions, besides equipment deliveries, on the provision of services, information exchanges with Russian partners, and engagement of Western companies in the most technologically challenging projects;
3) the third round was introduced in mid-February 2015 and targeted a number of Russian officials and nine new companies were introduced.

The sanctions regime against Russia include a number of restrictions within the fields of shipping and offshore. The offshore petroleum sector is one of three sectors that form the so-called economic sanctions against Russia, which include measures targeting certain aspects of sectoral cooperation and exchanges with Russia.[44]

Forbidden

The U.S. sanctions against Russian economy are stricter than the ones imposed by the EU and Canada. They apply to licensing of Russia-bound supplies of equipment for deepwater (over 500 feet, or 152.4 m) hydrocarbon production, development of the Arctic shelf and shale oil and

[44] The other two are the defense and the finance sectors. For more information, see https://svw.no/contentassets/6a4549f3d6a946f8820891b069de0752/the-sanctions-regime-against-russia-and-the-effects-on-the-offshore-community.pdf

gas deposits. The EU sanctions apply to deep-water hydrocarbon production, but do not specify the minimum depth of production.

For deep-water, Arctic and shale projects the following equipment is prohibited by the U.S. for import into Russia:

- drilling rigs;
- parts for horizontal drilling;
- drilling equipment and well completion equipment;
- offshore equipment for Arctic operations;
- well logging equipment;
- well pumps;
- drill pipes and casing pipes;
- software for hydraulic fracturing;
- high pressure pumps;
- seismic exploration equipment;
- remotely controlled underwater vehicles;
- compressors;
- tube expanders;
- distribution cocks;
- risers.

The list of equipment prohibited by the EU for import into Russia includes equipment for offshore projects, deep water drilling and exploration of hydrocarbon fields in the Arctic, equipment for shale hydrocarbons projects, various types of pipes, and pumps for liquids. The EU also introduced a pre-approval procedure for deals involving equipment supply to the Russian Federation. Such approvals must be granted by the authorized government bodies of the countries in which the exporting companies are registered.

The U.S. restrictions do not provide any exemptions for contracts executed before 6 August 2014. However, the European authorities may issue a permit for delivery if the export is related to a commitment arising from a contract or agreement executed before 1 August 2014, i.e. before the EU sanctions effective date.

The sanctions are not limited to equipment deliveries only – they apply to the financial sphere and, therefore, the investment opportunities of Russian companies.

Moreover, Western companies are prohibited from continuing their cooperation with Rosneft, Gazprom, Gazprom Neft, LUKoil, and Surgutneftegas in joint projects of Arctic, shale and deep-water exploration and production.

Focusing on the Norwegian sanctions.

The Norwegian sanctions regulations against Russia are found in, "Forskrift om restriktive tiltak vedrørende handlinger som undergraver eller truer Ukrainas territorielle integritet, suverenitet, uavhengighet og stabilitet av 15. august 2014", as amended on 10 October 2014.

The Norwegian Foreign Minister stated that the Norwegian government would mirror the EU sanctions regime, includes the abovementioned Article 3a. However, Norway decided to specify and thereby narrow the wording when translating "supply of specialized floating vessels". The wording used in the Norwegian provision cited below is "supply of specialised floating facility". The Norwegian provision equivalent to the abovementioned Article 3a in the Council Regulation, Section 17a, is almost identical to Article 3a and reads as follows (our translation):

"Section 17a.

Prohibition against providing certain services to be used in the oil industry.

1. It shall be prohibited to provide, directly or indirectly, the following associated services necessary for deep water oil exploration and production, arctic oil exploration and production, or shale oil projects in Russia:

(a) drilling

(b) well testing

(c) logging and completion services

(d) supply of specialized floating facility.

2. The prohibitions in paragraph 1 shall be without prejudice to the execution of an obligation arising from a contract or a framework agreement concluded before 11 October 2014 or ancillary contracts necessary for the execution of such contracts.

3. The prohibition in paragraph 1 shall not apply where the services in question are necessary for the urgent prevention or mitigation of an event likely to have a serious and significant impact on human health and safety or the environment.

It is worth emphasizing the difference from the American sanctions regulations is that the prohibition against the four specified key services does not apply for the fulfilment of contractual obligations which follows from "a contract or framework agreement concluded before 11 October 2014 or ancillary contracts necessary for the execution of such contracts", ref. paragraph 2 as cited above. Whereas the American company Exxon Mobile had to stop all drilling operations in Russia in 2014 following only a short grace period, Norwegian companies which would fall under the scope of Section 17a could continue obligations under contracts entered into before 11 October 2014. This provision has obviously and considerably reduced the negative effects of the EU sanctions regulations.

At the same time, it is difficult to give a general statement in an article as regards which types of facilities would be included, as there are always borderline examples – when is a "facility" a "vessel" and the other way around. The definition of "facility" as provided in the Norwegian Petroleum Activities Act of 1996, Section 1-6 litra d, includes;

"…installation, plant and other equipment for petroleum activities, however, not supply and support vessels or ships that transport petroleum in bulk. Facility also comprises pipeline and cable unless otherwise provided".

The individual supply of pipelines and cables would not be covered by Section 17a, but could easily be in breach of the provision in Section 17[45].

It is worth noting as well that the offshore area around the island of Sakhalin in the Sea of Okhotsk has not affected by the sanctions because most or all of the oil fields in this area are located at depths of less than 152 meters, and would therefore not be considered as "deep sea exploration and production".

2.5. Environmentalists' protesting as a societal institutional pressure

Greenpeace environmental groups try to stop continued expansion of the oil industry into new frontiers, particularly into the Arctic seas. Suing oil companies and governments to ban oil drilling and secure Arctic protection, they promote their protest actions, as *"This is the people versus Arctic oil"*[46].

Here are several examples of the protest actions by Greenpeace activists in the Arctic:

- In October 2016, environmental groups launched legal action under Norway's constitution, arguing that awarding of new exploration licenses in the Barents Sea breaches the right to a healthy environment. Norway's constitution was amended in 2014 to give every person "the right to an environment that is conducive to health and to a natural environment whose productivity and diversity are maintained" and that "natural resources shall be managed on the basis of comprehensive long-term considerations which will safeguard this right for future generations as well". In contrast, oil companies argue that it is wrong to conflate the Norwegian Barents Sea, which is largely ice-free, with other parts of the Arctic, imprisoned by ice for much

[45] For more information, see https://svw.no/contentassets/6a4549f3d6a946f8820891b069de0752/the-sanctions-regime-against-russia-and-the-effects-on-the-offshore-community.pdf

[46] Available at: http://www.greenpeace.org/usa/this-is-the-people-versus-arctic-oil/

of the year. Equinor and Lundin argue the drilling in the Barents Sea is just little different from the rest of the NCS and quite similar to the conditions in the North Sea.

-

"The world needs more oil and energy than renewables can provide" as Equinor emphasizes[47].

- In August 2017, the Greenpeace activists protested Equinor's drilling at the Korpfjell project in the Barents Sea by entering a 500-metre safety perimeter around the rig "Songa Enabler" with kayaks and rubber boats. The rig's crew stayed on board, but the drilling operations were stopped for several days. The Greenpeace "Arctic Sunrise" ship were towed away to Tromsø. The Greenpeace activists (6 persons + the captain of the "Arctic Sunrise") were arrested and then fined.

Figure 18. Greenpeace protesting at Korpfjell in August 2017 (Source: Greenpeace).

As commented by the representative of Equinor company: *"Actually it was illegal and irresponsible for entering the safety zone. The activists violated the Law. The crew on the rig called the police to intervene. The coast guards reacted to the call shortly"*. In contrast, Truls Gulowsen, head of Greenpeace Norway, argued Greenpeace considered the arrest by Norwegian authorities to be unlawful as the protest was carried out in an area where the activists had a right to protest peacefully in accordance with the freedom of navigation act[48]. As told by the representative of

[47] Available at: https://www.ft.com/content/a5dacfda-94f8-11e6-a1dc-bdf38d484582
[48] Available at: https://thebarentsobserver.com/en/ecology/2017/08/greenpeace-activists-released-after-oil-protest

Equinor company: *"The protest was that oil and gas industry is the main carbon dioxide-emitting source in Norway. They prepared an official complaint at the end of May 2017 to the authorities that Norwegian company Equinor had to stop developing this area before the drilling operations started. According to their claim, the Norwegian authorities should not open the Barents Sea for oil/gas development".* Despite a number of drilling operations, carried out in 2017 in the Barents Sea, the Korpfjell project has been of special interest because this area is new, more sensitive and remote than other licenses and attracts public attention, according to Equinor's representative.

- In June 2015, thirteen activists in kayaks intercepted Shell's drilling rig in Seattle prepared to depart for the Arctic. That was a boycotting action by Greenpeace activists against Shell in response to the oil company receiving the final go-ahead from the American government for drilling in Alaska. Shell had to abandon its controversial drilling operations in the Alaskan Arctic in the face of mounting opposition in what the environmentalists described as "an unmitigated defeat" for big oil.

Figure 19. Greenpeace protesting in Seattle against Shell company (Source: Greenpeace).

- In August 2013, the Greenpeace ship "Arctic Sunrise" sailed into the Barents Sea to enter the international waters of the Kara Sea and protest Rosneft's operations in the Arctic. The "Arctic Sunrise" was refused permission three times by the Russian authorities to enter the Northern Sea Route although the refusal is in violation of international law including the right to freedom of navigation. They stayed in the Kara Sea about 3 days and then left the Northern Sea Route, after the Russian coastguard boarded the boat and threatened to use force if they would not leave the international waters of the Kara Sea.

- In September 2013, the Greenpeace activists organized the protest near Prirazlomnaya platform in the Pechora Sea in order to try to prevent it from drilling earlier in the week. Two activists scaled the side of the Prirazlomnaya oil platform and folded out banners, despite being blasted with water. The ship was subsequently towed by a coastguard vessel to the Russian Arctic port of Murmansk. The crew consisted of 28 activists and 2 freelance journalists from 16 different nationalities. The Russian government intended to charge the Greenpeace activists with piracy, which could carry a maximum penalty of fifteen years of imprisonment.

Figure 20. Greenpeace protesting near the Prirazlomnaya platform in 2013 (Source: Greenpeace).

Figure 21. The attempt of Greenpeace activists to climb aboard the platform to stop its operations (Source: Greenpeace).

Although that Greenpeace International action was dramatic, but it also made <u>possible positive changes in Russian policies regarding the Arctic:</u>

- Russia announced in the Arctic Council that it would support a legally binding international agreement against oil pollution of the Arctic Seas. That's exactly what Greenpeace has been fighting for;
- Russia's President Putin tasked the Russian Government and oil companies with preparing measures on protecting the Arctic biodiversity from oil spills in cooperation with scientists and NGOs;
- Gazprom made an effort to improve its notoriously weak oil spill contingency plan for Prirazlomnaya;

- The Russian Ministry of Environment at last acknowledged the huge scale of the oil spill problem in Russia and promised to employ new technologies to improve the situation;
- Greenpeace Russia pointed out that according to current Russian regulations an offshore oil rig like Prirazlomnaya is allowed to extract oil for two years without training its personnel on how to respond to an oil spill. The Ministry of Emergency has since drafted amendments that would change this absurd situation[49].

[49] Available at: http://www.greenpeace.org/international/en/news/Blogs/makingwaves/how-peaceful-protest-made-positive-change-in-Russia/blog/50222/

3. LOGISTICS OPERATIONS IN DIFFERENT CONTEXTS

Offshore production is an extremely challenging and resource-intensive process. It is not just the construction of the complex process platform, from which the drilling is performed and where people involved in the field's development live and work. It means the establishment of the continuous logistics scheme to guarantee stable facility operation, which is a difficult task as well. Maritime transport is the basis of logistics and supply chains for these kinds of projects. It is not so difficult to imagine how many additional issues arise when it comes to transportation in an Arctic ice harsh location.

The logistics scheme of any offshore project can be divided into three main constituents:

- delivery of cargoes to the platform to support operation and personnel needs
- transportation of produced oil
- transportation of personnel.

Each offshore project of oil/gas development requires its own unique logistics scheme and supply chain. It has to take into consideration the climatic conditions, weather limitations and distances, influencing on the number of offshore supply vessels, its variety, and supply linkages with the shore base. It is estimated on average 4.2 thousand tons of materials and equipment to be delivered to the platform for the construction and operation of only one well. It is the equivalent of a large railway train, loaded with pipes, chemicals, bulk materials, etc. required for well construction. This figure may vary a little depending on the well type (production, injection, cuttings), methods of recovery enhancement, etc.

The development of offshore oil and gas fields involves a wide range of marine assets, including the variety of ***offshore service vessels (OSVs)***. Generally, OSVs provide support services to offshore floating drilling rigs, pipe laying and moored or fixed production platforms, utilized in exploration and production activities.

There are three main categories of OSVs:

- **Platform Supply Vessel (PSV):** designed for transporting supplies to the rigs and oil platform and return other cargoes to shore. The supplies include fuel, fresh water, equipment, drilling consumables, stores and provision for the operation of the oil platforms and for the personnel onboard. A typical PSV operating profile shows the vessel spending about 25% of the time in harbor loading and unloading, 40% sailing at a service in the 13-16 knot range and 35% loading or discharging at sea.

- **Anchor Handling Tug Supply Vessel (AHTS)**: designed to tow rigs from one location to another, to lift and position the rigs' anchors.
- **Construction Support Vessel (CSV):** used for subsea operations, and are typically equipped with a large crane, heli-deck, and large deck space.

Further, we present the specific cases and supply logistics operations of certain offshore installations in order to examine and identify the main features and challenges when managing logistics operations at various Arctic localities to ensure SAR and emergency preparedness.

3.1. Norwegian Barents Sea fields

3.1.1. Case 1. Goliat project

3.1.1.1. Field location and natural conditions

General info and location:

The Goliat oil offshore field is located in production license PL229 (7122/7-1), which was awarded in the "Barents Sea Round" in 1997. The licensing round was initiated by the authorities in order to promote interest in the Barents Sea as an oil and gas region. The discovery was made with the first exploration well in 2000. This is the first oil offshore field in the Norwegian sector of the Barents Sea.

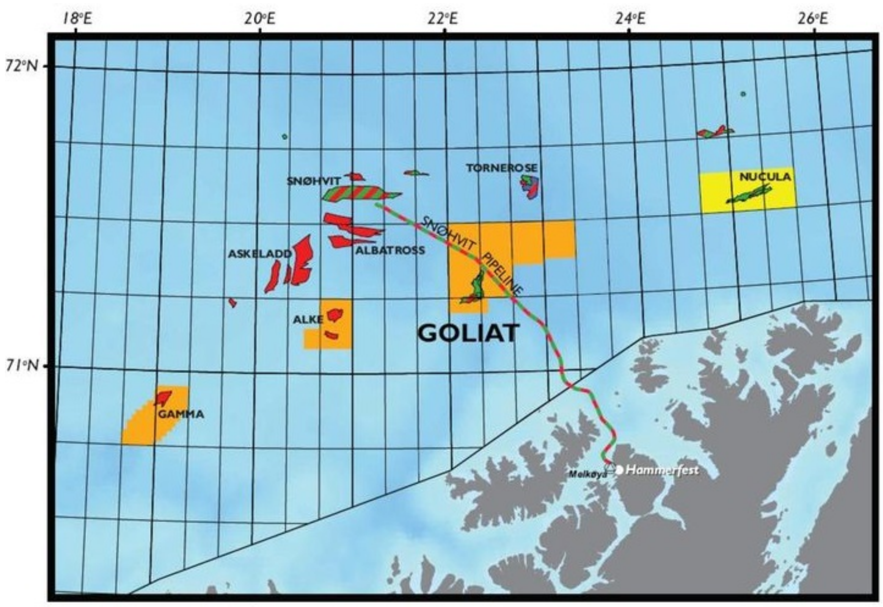

Figure 22. The location and coordinates of the Goliat field (Source: ENI Norge).

The license stakeholders are Eni Norge AS (operator, 65%) and Equinor Petroleum AS (35%). The field development concept was approved by the Government of Norway on 8 May 2009. It was developed on the basis of comprehensive impact assessment.

Estimated recoverable oil reserves are about 180 million barrels of oil. Estimated recoverable gas reserves are 8 billion Sm3. Annual operating costs are approximately NOK 1.5 billion.

The production with offshore loading started in March 2016. The field will produce 100,000 barrels of oil per day (65,000 boe net to Eni). The field is estimated to contain about 180 million barrels of oil and production is assumed to continue to contain about 180 million barrels of oil for 10–15 years. Production will be facilitated using a subsea system consisting of 22 wells (17 of which are already completed). There are twelve production wells, seven water injectors and three gas injectors. The associated gas is reinjected to increase oil recovery and transported to the processing plant at Melkøya 2007 Barents Sea Subsea to Shore LNG (Snøhvit field).

The Goliat field is located 88 kilometers (53 miles) northwest of Hammerfest, in water depths of 341 m.

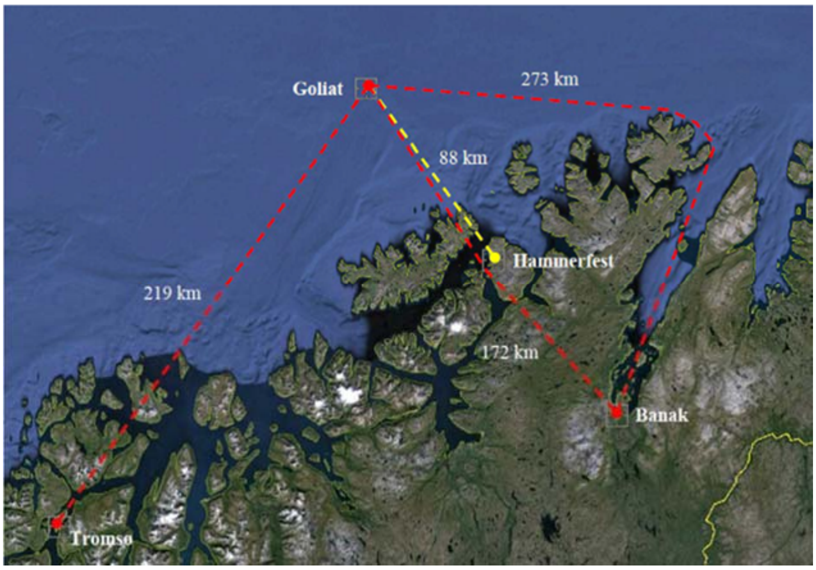

Figure 23. The location of the Goliat field and its remoteness from key onshore centers (Source: ENI Norge).

<u>Natural conditions</u>**:**

The Goliat field is located in the South-Western Norwegian Barents Sea. This region lies within the region that is considered to be Arctic.

Air temperature:

Average temperatures vary between 0 and 2.7^{0}C. The extreme minimum air temperatures are significantly lower than what is commonly experienced in other parts of the Norwegian shelf. Winter temperatures can reach up to – 30^{0}C / -34^{0}C. The minimum average temperature in January/February are expected to be around -15°C.

Figure 24 shows the 100 years temperature range in course of a year:

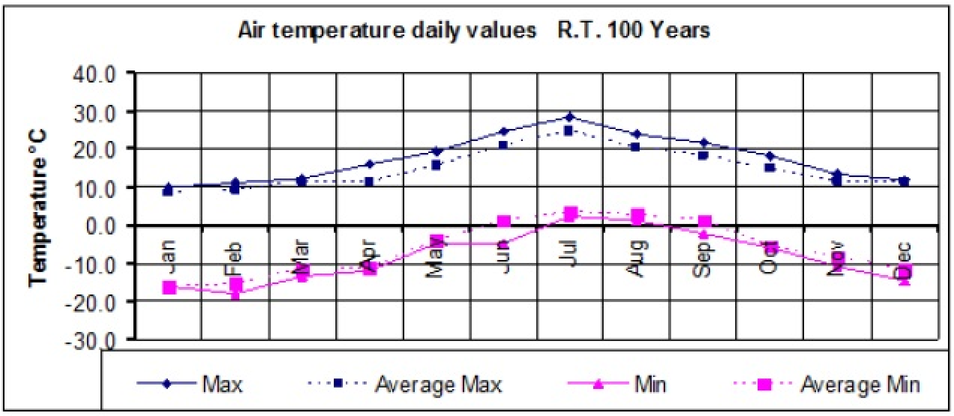

Figure 24. Expected temperature range for the Goliat field (Rekdal, 2012, p. 7)

Ice and icebergs:

There is a low probability of sea ice and icebergs occurring at the Goliat location (NORSOK, 2007, p. 27)[50]. It is anticipated that any sea ice in the South-Eastern Barents Sea will not form locally, but will drift in from areas further north-north-east. The reason for this is the dominant ocean currents that bring warm Atlantic waters into the Southern Barents Sea. In order for ice to enter these areas, a north-north-easterly wind is required over an extended period. However, local formation of ice in the northernmost blocks cannot be ruled out, and the use of weather forecasts will be vital for predicting any local freezing.

An important prerequisite of the authorities is that drilling in oil-bearing layers must not take place closer than 50 kilometers to the marginal ice zone. The authorities have defined the marginal ice zone as the transition between offshore areas covered by more than 40% ice and open sea. Thus, exploration drilling will not take place if sea ice drifts towards the drilling location. In practice, this is managed by monitoring large expanses of water and monitoring sea ice. If sea ice approaches a drilling location, drilling activity will cease in anticipation of the ice receding to a point at least 50 kilometers from the drilling location. Sea ice closer than 50 kilometers will cause disruption to a drilling operation and will delay exploration. Statistics on the occurrence of sea ice

[50] Sea ice is ice that forms when the sea level temperature drops below freezing (-1.9 C^{0} for salt water). It is this type of ice that constitutes what is known as the “marginal ice zone” (also known as the “ice edge” in the Norwegian debate). Problems associated with sea ice, and especially the marginal ice zone, have been the subject of discussion over the last couple of years when the issue of oil and gas activity in the Barents Sea has been addressed.

makes it possible to estimate how often such events may occur in selected locations, as well as the expected waiting time before operations can resume.

There is a possibility for occurrence of icebergs. Icebergs are affected by wind, currents and waves and normally move at a speed of around 0.7 km/h. The most important sources of icebergs in the Barents Sea are the glaciers on Franz Josef Land. Normally, circulation in the Barents Sea will drive the icebergs west towards the eastern coast of Svalbard, but in certain years with northerly winds, they can drift relatively far south.

Wind:

Polar lows are relatively uncommon and will not affect the companies' ability to operate in the South-Eastern Barents Sea.

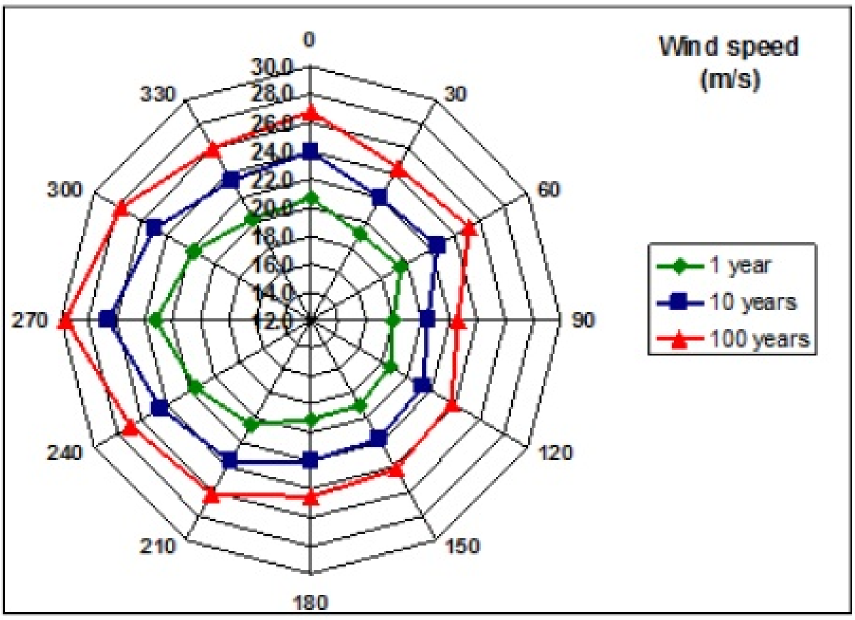

Figure 25. ***Expected wind speed/ direction for the Goliat field (Rekdal, 2012, p. 7)***

According to Figure 25, rather high wind speeds can be expected primarily from a western direction. The maximum wind speed to occur in 100 years equals 30 m/s; in 10 years, this value equals approximately 27 m/s and every year 26 m/s. Average wind speed is 8.3 m/s.

Weather data shows that strong winds from the western direction are significantly warmer then the less strong winds from the eastern direction. Thus, the possibility for a combination of cold temperatures and strong winds, which will lead to a strong wind chill effect, is low.

Waves and current:

Average wave height for all areas in the South-Eastern Barents Sea is about 2.1 m, with an extreme significant wave height of approximately 13.8 m (100-year sea state). For individual waves an extreme wave of approximately 26 meters has been estimated, while an extreme wave crest has been estimated at 15.5 meters above calm water.

The ocean current conditions also have characteristics similar to those in the Western North Sea and will therefore be conditions that the industry is used to operating in. For example, the ocean currents in the Norwegian trench and in the Troll field are significantly more dynamic than in the South-Eastern Barents Sea.

Snow and icing:

Experience from previous exploration activity indicates that wind significantly reduces the volume of snow that accumulates on rigs, to the extent that even extreme snow loads are expected to be manageable. However, it will be important that all operators consider preventative measures such as mechanical or thermal removal, for example. Ice accumulation from sea spray could occur under specific climatic conditions relating to wind strength, water and air temperature. Thus, polar lows, snow and icing must be taken into account in the planning and implementation phases of any exploration activity during winter.

3.1.1.2. Field logistics: offshore/onshore infrastructure

Offshore supplies:

The Goliat platform is a floating, production, storage and off-loading unit (FPSO). It was designed by Norwegian company Sevan Marine. The Goliat FPSO is designed and built both to withstand icing and to ensure that rain and snow drain naturally from the walls and roofs. Goliat is a geostationary FPSO and the tanker can move relative to the platform in response to prevailing weather conditions. The hose is longer than what is normally used, almost 400 meters. The system is housed in an enclosure to prevent icing.

Figure 26. Goliat FPSO preparations in full swing (Source: Offshorenergytoday.com)

The Goliat FPSO is served by a fleet consisted of 2 supply vessels, 1 standby vessel and 3 shuttle tankers. Two supply vessels are equipped for mechanical oil recovery and dispersal operations:

- *"Esvagt Aurora"* – a contingency vessel equipped for both mechanical oil recovery and dispersal operations. Oil-detecting radar and IR cameras provides the vessel with the ability to operate regardless of daylight conditions. The oil boom systems and skimmers are stored below deck and, thus, is well-protected from winter conditions, while at the same time providing a good working environment for the crew. The winterized vessel is able to meet the most recent oil spill contingency standards (NOFO2009). It will be a rescue operations resource and will increase towing vessel capacity in the region.

Figure 27. "Esvagt Aurora" contingency vessel

- *"Stril Barents"* – designed and built to operate as a supply and stand-by vessel at the Goliat location. Under normal circumstances, the vessel operates mainly as a supply vessel. It is also able to replace Goliat's current standby vessel, Esvagt Aurora, and provide the first response both in case of emergency life-saving intervention and oil spill situations. This double function makes the vessel unique on the Norwegian shelf.

Figure 28. "Stril Barents" supply and stand-by vessel

Three tankers serve the Goliat project. Two Knudsen NYK Offshore Tankers transport Eni Norge's share of oil production to the market from the Goliat field: "Torill Knutsen" and "Hilda Knutsen". These tankers work at Goliat on a weekly basis to collect 850 000 barrels of oil from the Goliat FPSO. Equinor collects its share of Goliat production using its own tanker: "Eagle Barents".

Table 1. ***Vessel engaged in the Goliat project.***

Vessel	Ice class	Characteristics	Additional equipment	Owner	Built	Flag
"Esvagt Aurora"	+1A1, ICE-1C	Contingency vessel	Oil.rec. - oil-detecting radar and IR cameras, Winterized by oil boom systems and skimmers, FiFi I	ESVAGT (in Esbjerg)	2012 – Zamakona Shipyard, Bilbao, Spain	Denmark
"Stril Barents"	+1A1	Supply/stand-by vessel	Oil.Rec. - oil-detecting radar and IR cameras, NOFO2009	Simon Møkster Shipping	2015 – Vard Aukra	Norway
"Skandi Iceman"	DnV-GL +1A1, ICE-1B	AHTS	Winterized, oil.rec. – NOFO2009, FiFi I+II, DYNPOS-AUTR, 300 evacuees	DOF Group	2013 - VARD TULCEA	Norway
"Torill Knutsen"	+1A1, ICE-1C	Crude oil / Shuttle tanker		Knudsen NYK Offshore Tankers AS	2013 - Hyundai Heavy Industries	United Kingdom
"Hilda Knutsen"	+1A1, ICE-1C	Crude oil / Shuttle tanker		Knudsen NYK Offshore Tankers AS	2013 - Hyundai Heavy Industries Co. Ltd	United Kingdom
"Eagle Barents"	Arc 6	Shuttle tanker		AET Sea Shuttle AS	2015 - Samsung Heavy Industries	Bahamas

<u>Onshore operations and facilities:</u>

The operational organization and support functions for the Goliat project are located in Hammerfest, where Eni Norge AS established its regional office. Between 40 and 60 persons work at Eni Norge's offices in Hammerfest. Eni Norge AS is currently establishing a supply and helicopter base in Hammerfest, including provision for logistics and maritime services. In total, this will create between 150 and 200 directly-related jobs.

The main offshore supply facility is Polarbase supply base in Hammerfest, which is responsible for inbound deliveries of all supplies to the base and waste transportation from the base by using "Bring-Logistics" trucks.

Two supply bases for emergency equipment are located in Hasvik municipality and Måsøy municipality.

Figure 29. Two supply bases for emergency equipment in Hasvik and Måsøy municipalities (Source: Eni Norge)

The availability of onshore resources like AWSAR helicopters and hospitals is extremely limited: in Hammerfest, at UNN in Tromsø, in Longyearbyen. That increases potential risk factors.

3.1.1.3. Emergency preparedness logistics: SAR and oil spill response; challenges and accidents

There are several challenges to SAR and oil spill preparedness in this region. These are, among others:

- Closeness to coast – short drifting time to shore
- Environmental sensitive areas
- Distances and limited infrastructure
- Long response time for resources from the Norwegian Sea and the North Sea
- Limited access to personnel resources
- Light conditions and icing during winter season[51].

[51] Available on http://www.arctic-council.org/eppr/wp-content/uploads/2012/06/Eni_Oil_Spill_Preparedness_Workshop_Kirkenes_June_2012.pdf

- A light type of crude oil

In order to ensure safe and efficient working at the Goliat field, Eni Norge introduced integrated operations, based on the proactive use of real-time data, analytics and interaction encompassing offshore and onshore organizations and suppliers. Eni Norge established a new office in Hammerfest and in Stavanger to facilitate efficient interaction. According to Managing Director Eni Norge, Phillip Hemmers,

"Nothing is so urgent or important that we cannot find the time to do it safely".[52]

To increase coherence and test the Goliat contingency equipment, in September 2012 the exercise, known as "Barents Solutions 2012", was conducted to verify for the first time that Eni Norge's contingency plans were fully functional and effective prior to the field coming on stream. That exercise was a joint effort between Eni Norge AS, Equinor and NOFO. Several public and private sector partners also contributed with personnel and equipment. It was carried out as a combination of oil spill and other practical exercises, which involved the use of actual contingency resources during all phases of an oil spill response, the practical training of crews and personnel, several vessels and other types of contingency resources. The principal activities took place in Hammerfest, Nordkapp, Måsøy and Berlevåg municipalities[53].

Several new principles to strengthen integration activities and cooperation and increase the level of emergency preparedness were applied and put into practice after the exercise. It has related to the use of fishing vessels for coastal contingency operations, and separate task forces or operational teams of professionals linked to emergency response actions along the coastlines and beaches.

As told by the interviewee of Norwegian oil company #1:

"The NOFO uses also fishing boats, which main task is to tow equipment that collects, records and stores oil. They started to use them at the Goliat project and then extended to the Korpfjell project in 2017. It turned out to be efficient and profitable to use the fishing fleet, because fishing boats are small. It makes the oil recovery preparedness more effective and adapted to local conditions. The agreements with local fishing boat owners became an important contribution to realizing this goal. Fishing vessels are now used along the entire Norwegian coast. It's good

[52] Available on http://www.eninorge.com/en/News--Media/Multimedia-archive/Film/
[53] For more information see Press Release, September 11, 2012 that is available on https://www.offshoreenergytoday.com/oil-spill-drill-at-goliat-field-norway/

cooperation between the petroleum and fishing industries".

The responsibility between Eni Norge and NOFO for the emergency preparedness operations was redistributed as follows:

1) Eni Norge: for emergency preparedness; environmental impact analysis; emergency preparedness analysis; dimensioning of preparedness resources;

2) NOFO administers and maintains the oil spill preparedness resources on behalf of the operators.

Therefore, 6 NOFO-systems were organized for offshore and coastal preparedness during production drilling at Goliat:

- Improved open sea emergency preparedness (Barriers 1 and 2):
  - Detection and monitoring
  - Standby vessel "Esvagt Aurora" – NOFO2009 standard (1800 m^3)
  - Additional available resources.

The standby vessel "Esvagt Aurora", which is constantly on duty near the Goliat platform, also took part in the exercise. This vessel serves as a valuable resource during any rescue operations, as well as reinforcing the capacity of the towing vessels in the area. The on-board oil spill protection equipment is stored below deck, and is optimized for cold conditions and winter operations. Advanced monitoring equipment on board makes it possible to discover and follow up any oil spills, under any light conditions. These monitoring systems are part of the modernization of Norwegian oil spill contingency strategy.

In addition, two supply vessels have minimum NOFO 2005 standard. All supply vessels are equipped with infra-red cameras and oil-detecting radar.

Eni Norge uses a set of integrated platforms to detect and monitor immediate discharges from the Goliat field:

- Satellite +Sensors on the subsea templates;
- Plane and helicopter (SAR, SLAR, IR)
- Installation (radar, IR) + Stand-by vessel (radar, IR)
- ROV on the stand-by vessel
- Land based installations (HF radar)

Figure 30. The concept of emergency preparedness to SAR and oil spill response (Source: Eni Norge).

- Improved coastal and shore zone preparedness (Barriers 3 and 4):
  - 30-40 fishing vessels in permanent preparedness
  - New task force/ operational groups in the coastal and beach zone

A new operational "response team" concept was adopted to improve preparedness in the coastal zone. The operational unit was specially adapted for oil spill recovery operations in the coastal zone and it consists of:

- Vessels with emergency preparedness contract with NOFO (oil spill certificate);
- Light and mid-weight boom systems, skimmers and storage units;
- Support vessel within oil spill monitoring equipment and tactical command;
- Experience from the oil spill contingency in Prince William Sound, Alaska.

Figure 31. Operational “response team” with the participation of fishing vessels (Source: Eni Norge)

- Infrastructure, logistics and remote sensing (all barriers):
  - Use of new monitoring technology
  - Dedicated material to coastal and shore zone operations
  - Support vessel to coastal and shore zone operations
  - Detailed mapping of the coastal zone
  - Equipment in new depots: Hasvik and Måsøy municipalities
  - Detailed contingency plans for selected areas
  - Holistic logistics plan.

3.1.2. Case 2. Johan Castberg project

3.1.2.1. Field location and natural conditions

General info and location:

The Johan Castberg (formerly Skrugard) field development Project is the largest oil field yet to be developed on the Norwegian continental shelf (NCS) The licence is PL 532. The field’s resource base consists of the three oil discoveries Skrugard (in April 2011), Havis (in January 2012) and Drivis (May 2014). All three fields are assumed to share common infrastructure.

The license stakeholders are Equinor (50%), Eni Norge As (30%) and Petoro AS (20%). The operator is Equinor.

The field is located in the Norwegian Barents Sea in blocks 7219/9 and 7220/4,5,7, approximately 240 km north-west of Hammerfest, nearly 240 km from Melkøya, 150 km from

Goliat field, and about 100 km north of the Snøhvit-field. Johan Castberg and Havis oil fields are located at a distance of about 7 km from each other. The water depth is about 360 -390 meters.

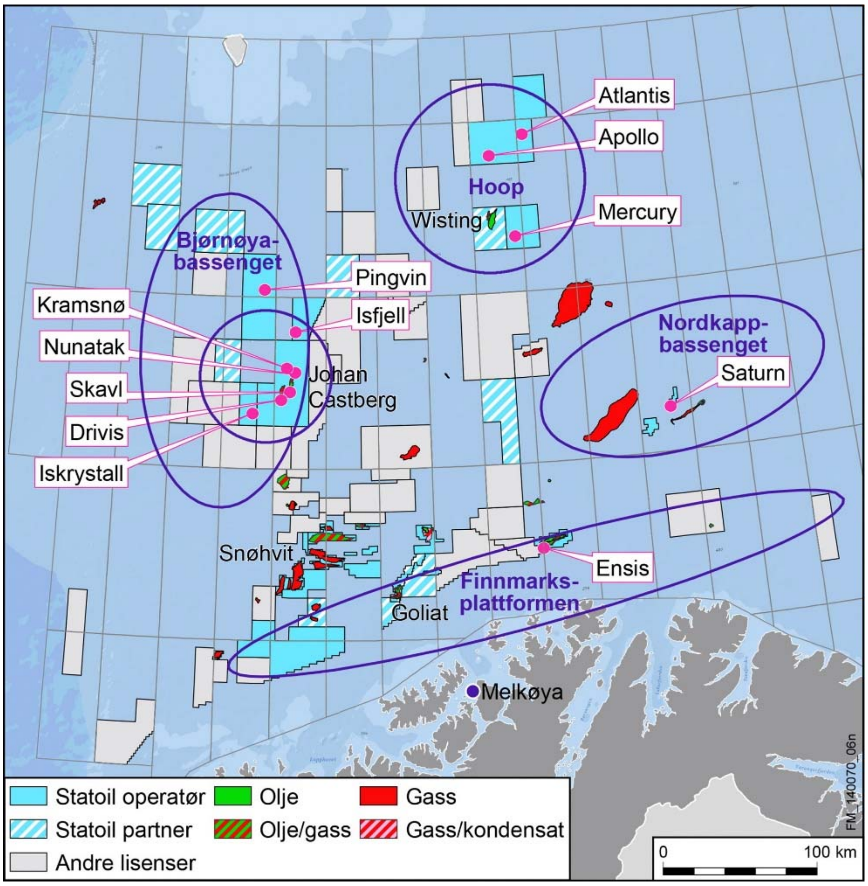

Figure 32. The location of the Johan Castberg field (Source: Equinor).

The current recoverable reserves are estimated at being 400 to 600 million barrels of oil. The production capacity of the field is estimated at 200,000 barrels of oil equivalent each day.

The first phase of the Johan Sverdrup development will be completed in the period 2018-2022. As told by the interviewee of Norwegian oil company #1:

"The initial costs for the project development were estimated approximately NOK 1.15 billion annually to operate the Johan Castberg field – the huge amount and the main reason to postpone the project! During our improvement work, we conducted several logistics studies and found new cost-effective solutions that allow us to realize the project. Now the estimated investments are NOK 50-60 billion. There is a lot of preparation work still. The drilling operations is about 40 wells for 4-5 years and the oil production to be started in 2022. The most important what we experienced is that the logistics solutions are primarily the main driver for cost-effectiveness of the project."

In December 2017, the capital expenditures for the Johan Castberg project were estimated at some NOK 49 billion, according to the new plan for development and operation that is able to make the project development be profitable even at oil prices of less than USD 35 per barrel[54].

3.1.2.2. Field logistics: offshore/onshore infrastructure

Offshore facilities:

The Johan Castberg field is assumed to be developed using a floating, production, storage, and offloading (FPSO) unit and production vessel with additional subsea solutions.

November 10, 2017 Equinor signed a letter of intent with Sembcorp Marine Rigs & Floaters Pte. Ltd in Singapore for the construction of the hull and integrated living quarters for the floating production, storage and offloading (FPSO) vessel that will be located on the Johan Castberg field in the Barents Sea[55] (See Figure 33).

Figure 33. Johan Castberg floating production vessel (Source: Equinor)

Oilfield services provider Aker Solutions will supply the subsea production system and design the topside of the floating production, storage and offloading (FPSO) facility, which will be the largest-ever of its kind offshore Norway. The subsea production system will consist of 30 wells with vertical subsea trees, wellheads, control systems, 10 templates and manifolds, two satellite structures and tooling. Initial deliveries are scheduled for the second quarter of 2019 with final delivery in the first half of 2023. The FPSO agreement covers engineering, procurement and management assistance for the detailed design of the Johan Castberg topside. The detailed design is set to be completed in 2019[56].

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[54] For more information, see https://www.Equinor.com/en/news/05dec2017-johan-castberg.html
[55] For more information, see https://www.Equinor.com/en/news/10nov2017-johan-castberg.html
[56] For more information, see https://www.offshoreenergytoday.com/aker-solutions-lands-johan-castberg-work-worth-over-480m/

As told by the interviewee of Norwegian oil company #1 about how effective logistics solutions for the project can be found at the stage of preparation:

"We look into the demand and what we are going to do with the drilling rig at the Johan Castberg project. Taking into account that the distance is about 140 nm from Hammerfest, we estimate 10 hours that the supply vessel needs. Then, we estimate that it can be enough to support the rig by using 1 supply vessel to make 3-4 trips per week. In addition, we have 1 stand-by vessel that should be at place when we start drilling operations. There are on-going talks of what kind of stand-by vessel should be and what tasks it has to resolve like oil recovery and emergency response. Now it is assumed to use a multifunctional vessel if it is possible. We also have 1 transport helicopter and 1 SAR helicopter from Hammerfest to be shared with ENI's Goliat project in order to reduce costs. We share 50/50% of all costs for the helicopters that is a good solution. The use of a SAR helicopter costs about NOK 100 hundred million per year and a transport helicopter for the crew shift is NOK 80-90 million per year."

Transportation of the produced oil from the offshore site to the onshore oil storage facility will be carried out by a pipeline measuring 280 km in length. The oil will be stored in two mountain caverns. It will be transferred to the quay through a pipeline. Crude tankers will further transport the oil from the terminal.

Onshore operations and facilities:

The main onshore facilities will be located at Polarbase supply base in Hammerfest.

The Equinor's new plan for development and operation at Johan Castberg required expanding the Polarbase supply base, owned by NorSea Group. It will be invested NOK 60 million, with Hammerfest harbor, to build a new Roll-on/Roll-off facility at the Polarbase as it expects more workload in the area when the Johan Castberg field development begins[57].

According to the interviewee of Norwegian oil company #1:

"Our existing supply base in Hammerfest is well established and functions very well. We anticipate that new ro-ro facilities at the quay will allow for even more efficient loading and unloading work".

"In addition, we signed a new agreement with ASCO supply base, also located in Hammerfest, for the next 4 years of operations. Thereby, we just look for new solutions for cooperation to share supply vessels if it is possible to use them together somehow with Lundin.

[57] For more information, see https://www.offshoreenergytoday.com/Equinors-johan-castberg-move-spurs-norsea-to-expand-supply-base/

Lundin uses the ASCO base for their operations in the Norwegian Barents Sea. Actually, there is no lack of supply vessels. This is only due to high expenses, because to hire a supply vessel in the spot market it costs about NOK 200 thousand per day", as shared by the interviewee of Norwegian oil company #1.

3.1.2.3. Emergency preparedness logistics: SAR and oil spill response

While a well-developed emergency system is somehow available in coastal Norway close to the mainland, there is the limited preparedness capacity for search and rescue, hospital care and oil spill response in the Svalbard area. The remote location of onshore resources like AWSAR helicopters and hospitals (availability of onshore hospitals in Hammerfest, at UNN in Tromsø, in Longyearbyen) increases potential risk factors for the Johan Castberg development.

According to the interviewee of Norwegian oil company #1, it is expected to use one of emergency response and rescue vessels, which Equinor awarded new seven-year contracts in 2017 to two contractors - Simon Møkster Shipping and Havila Shipping. The vessels are part of Equinor's area-wide emergency response on the Norwegian continental shelf (NCS). Simon Møkster Shipping's vessels are the "Stril Poseidon", "Stril Merkur", and "Stril Herkules". Havila Shipping's vessels are the "Havila Troll", which took part in the Korpfjell drilling operations in August 2017[58].

As told by the interviewee of Norwegian oil company #1, the area emergency response vessels are required to be fitted with two MOB boats, fire-fighting equipment, a minimum 110-metric ton towing capacity, and an emergency hospital. In addition, they should carry oil spill response equipment such as oil booms and skimmers, with storage capacity for oil spill clean-up in accordance with NOFO requirements, oil dispersing equipment, a stern lifeboat recovery system, and a helipad.

3.1.3. Case 3. Korpfjell project in the North-East Barents Sea (PL859).

3.1.3.1. Field location and natural conditions

<u>General info:</u>

The Korpfjell oil field is one of the northernmost formations in the Norwegian Arctic waters. The license is PL859, which was awarded in the 23rd licensing round in 2016. The area in

[58] It is worth noting that today Equinor has a total of six emergency response and rescue vessels on the NCS, and one currently being upgraded to an adequate relief vessel, a 24-hour operations center at Sandsli, and five operative search and rescue (SAR) helicopters on the NCS. For more information, see http://www.offshore-mag.com/articles/2017/02/Equinor-extends-norway-emergency-vessel-deals.html

this license consists of 12 blocks: 7335/1, 7335/2, 7335/3, 7336/1, 7434/7, 7434/8, 7434/9, 7435/9, 7435/10, 7435/11, 7435/12, and 7436/10.

The license stakeholders are Equinor (30%), Chevron (20%), ConocoPhillips (15%), Lundin (15%) and SDØE (20%). The operator is Equinor.

The first exploration drilling operations of well 7435/12-1 were carried out in August 2017[59]. The main objective of the well was to prove oil in reservoir rocks. The well encountered a gas column of 34 meters in sandstone with good reservoir quality in the main target. The Korpfjell gas discovery is estimated to contain gross resources between 40 and 75 million barrels of oil equivalent (MMboe). The well proved a small, non-commercial gas discovery.

Korpfjell is the first exploration well drilled in the Norwegian section of a formerly disputed area between Norway and Russia, which was opened for exploration activity in 2013. It is also the northernmost wildcat well drilled on the Norwegian shelf, located on the 74th parallel.

According to the experts, more exploration is needed to understand the potential of this area. Further drilling is expected to take place in 2018 in PL859 to test additional prospects.

It is worth noting that the "Songa Enabler" was attacked by Greenpeace activists, who protested Equinor's drilling operations at the Korpfjell (See more details in Section 2.5).

<u>Location:</u>

The well 7435/12-1 at Korpfjell field is located about 415 km from the Norwegian coast, about 475 km from the Russian coast, 570 km from Hammerfest, about 365 km northeast of the Wisting discovery well 7324/8-1 in production license 537, and about 555 km from Novaya Zemlya (See Figure 34 and Figure 35). The water depth is 253 meters.

In addition, the Korpfjell is not only located far north, but also far east, only 37 km from Norway's maritime border to Russia. For Equinor, its location is of major interest because of its vicinity to the Perseevsky license area on the Russian side of the border. The Perseevsky block is located in the western Russian part of the Barents Sea in an area adjacent to the Norwegian economic zone. It covers 23,000 km^2 in water depths 120 – 250 meters. A first exploration well is to be drilled by 2020.

[59] Korpfjell is the fourth well in Equinor's 2017 exploration campaign in the Barents Sea, where the Kayak oil discovery was announced on 3 July, the Blåmann gas discovery on 17 July and Gemini North on 7 August. Then, the fifth well was Koigen Central in Equinor's campaign 2017 (the 1st author's note).

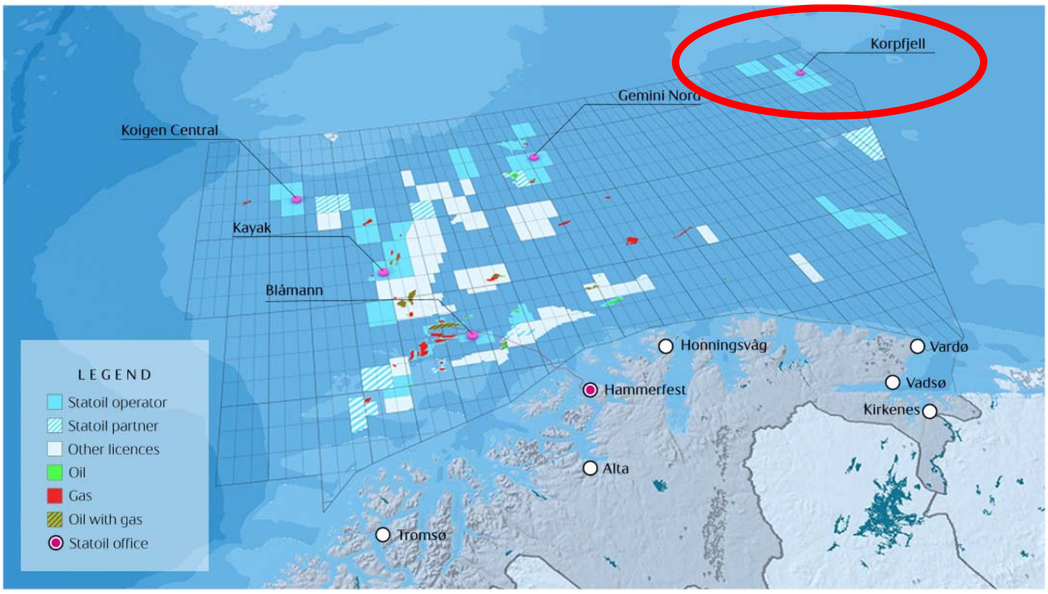

Figure 34. The location of the Korpfjell project in the Barents Sea (Source: Equinor).

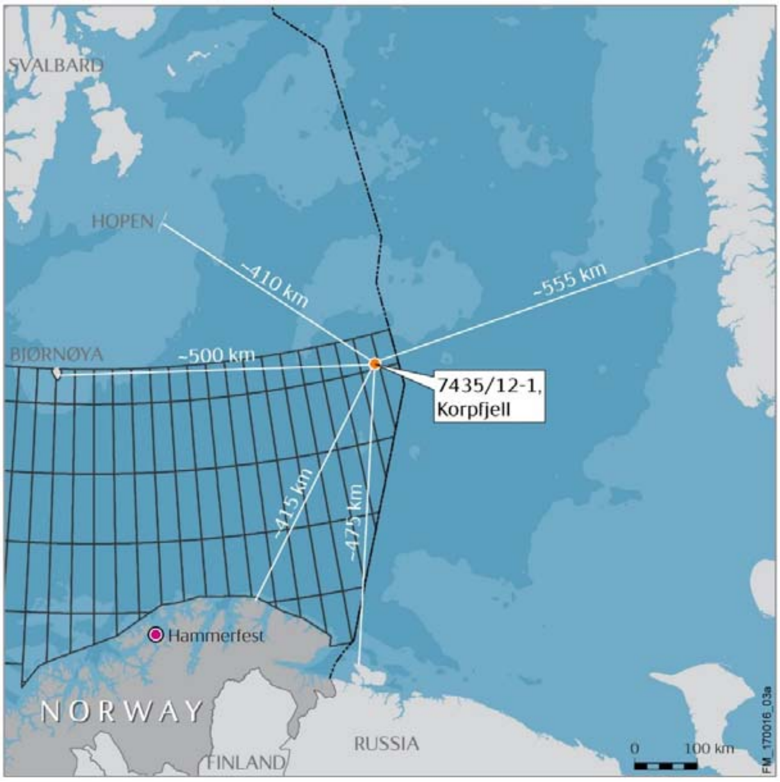

Figure 35. The distances of the Korpfjell field location in the Barents Sea (Source: Equinor).

Natural conditions:

In the Korpfjell area of the Norwegian Barents Sea, awareness must be given to low temperatures, heavy snowfall, icing and occurrence of sea ice and icebergs.

The average January sea temperature is close to 0^0C. The extreme minimum temperature for the last 100 years reached -34 ^{0}C. The average wind speed is 8.3 m/s. The extreme mean for the last 100 years was 30.5 m/s. The wave height is about 2.1 m, but the extreme wave height reached up to 13.8 m. The probability of ice intrusions during time-limited operations is low and negligible during summer months. Drill rigs are less vulnerable to snow and icing compared to minor vessels[60].

In the Korpfjell area, which is near the polar front, there is a relatively high likelihood of fog in summer and autumn. This may impose restrictions on some methods of mapping and monitoring an oil spill during an oil spill action and hence the effectiveness of the operation[61]. Data from the Norwegian Meteorological Institute show that there has been no ice during the summer months in this area during the last 50 years. Throughout the year, there has been extremely limited ice in all areas. During the last 14 years, there have been fewer than 10 days of ice near Korpfjell's location. The presence of ice for the area varies from a few days in 2011 to between five and six months in 1978, 1979 and 2003. However, the latter is a rare event for the period for which data exist. The tendency in the area is that there is an ever-decreasing presence of ice, and that the sea area is generally open almost all year.

3.1.3.2. Field logistics: offshore/onshore infrastructure

Offshore infrastructure and sea supplies:

The well was drilled by using the semi-submersible drilling rig "Songa Enabler" to a vertical depth of 1,540 meters below the sea surface and in a water depth of 253 meters.

"Songa Enabler" is a floating, self-propelled rig built in 2016 and designed specifically for cold climates. The rig was approved and classed by DNVGL for such conditions.

[60] From BaSec report: Barents East blocks Metocean Design Basis ME2015_005 (Equinor-2015). Available at: https://www.norskoljeoggass.no/Global/BaSEC%20rapporter/Introduction%20for%20authorities%20-%20MetOcean%20and%20Ice_EN.pdf

[61] The data is from Emergency preparedness analysis, available at: http://www.miljodirektoratet.no/Global/dokumenter/horinger/Petroleum/Beredskapsanalyse%20for%20letebr%C3%B8nn%207435-12-1%20Korpfjell%20-%20Equinor%20ASA.pdf?epslanguage=no

Figure 36. "Songa Enabler" rig in the Barents Sea (Source: Lundin).

When the well was permanently plugged and abandoned the rig moved to the Koigen Central prospect in licence PL718 in the western part of the Barents Sea.

<u>Maritime vessel availability:</u>

The support fleet for the Songa Enabler rig consisted of three vessels - "Havila Troll", "Troms Arcturus" and "Viking Queen" (See Table #2).

Figure 38. "Havila Troll" vessel (Source: Shipspotting) ***Figure 37. "Troms Arcturus" vessel (Source:Skipsrevyen)***

According to the interviewee of Norwegian oil company #1:

"One of the main challenges when developing the Korpfjell field is remoteness. Two vessels must be available for supplying the rig due to long distances and one standby vessel "Havila Troll" was on duty near the rig to meet requirements on oil spill preparedness".

The distance between the drilling site and the supply base in Hammerfest was 570 km that required 24 hours sailing per one way. Per week, each of two supply vessels - "Troms Arcturus" and "Viking Queen" - made two round trips between the rig and the supply base, as told by the interviewee of Norwegian oil company #1.

"Havila Troll" remained on duty 24 hours a day near the "Songa Enabler" rig to ensure emergency preparedness.

Table 2. ***Vessels engaged in the drilling operations at Korpfjell in 2017.***

Vessel	Ice class	Characteristics	Additional equipment	Owner	Built	Flag
"Songa Enabler"	DNV 1A1	Midwater floater	Helideck, mooring system	Songa Offshore	2016 - Okpo Shipyard - Daewoo Shipbuilding & Marine Engineering, South Korea	Norway
"Havila Troll"	DNV-GL, +1A1, ICE-1C	AHTS	Oil.Rec., oil-detecting radar, IR cameras, Winterized basic - by oil boom systems and skimmers, hospital, telemedicine equipment, FiFi I &II, MOB boat, 320 survivors	Havila Shipping	2003 – Havyard in Sogn, Norway	Norway
"Troms Arcturus"	DNV, 1A1 ICE-C	PSV	Oil.Rec., NOFO2009, 150 evacuators	Troms Offshore Manage-ment	2014 – Vard Aukra, Norway	Norway
"Viking Queen"	DNV 1A1, ICE-C	Supply vessel	Oil.Rec. NOFO209, FiFi II, gas fueled, 240 evacuators, MOB boat	Eidesvik Shipping AS	2008- Westcon Yard, Ølensvåg, Norway	Norway
"Esvagt Aurora"	DNV-GL, +1A1, ICE-1C	Standby vessel	Oil.Rec., oil-detecting radar, IR cameras, winterized basic - by oil boom systems and skimmers, FiFi I&II, 320 survivors	Esvagt	2012 – Zamakona Shipyard, Bilbao, Spain	Denmark

In addition, "Esvagt Aurora" vessel, engaged in the Goliat project, was included in the emergency plan for the Korpfjell project. This vessel stayed near the Goliat platform during the drilling operations at Korpfjell site, but it would support in case of any emergency (See Section 3.1.3.3. below for more details).

Aviation infrastructure:

During the drilling operations at Korpfjell site, which lasted four weeks, the rig's crew was changed by the helicopter. The crew flew to Korpfjell from Hammerfest and Kirkenes with refueling in Vardø[62]. The time of flying from Vardø took 1 hour 42minutes.

As told by the interviewee of Norwegian oil company #1:

"Due to the long distance and requirements on emergency preparedness, we could take on board the helicopter only seven passengers as maximum at each flight, because we needed extra fuel for the helicopter to reach the rig and back the shore base. The crew shift was in two weeks. So, if the crew on board the rig was 120 persons, we changed 60 persons per week. According to the Norwegian law, the rig personnel work two weeks and then are off during the next four weeks. As we planned initially, the helicopter's capacity was 98 persons: seven on board for 14 flights per week. However, there were some limitations for using the helicopter like the ordinary maintenance or inspection, which took one day or another per week. So, every week during the four drilling weeks, we changed 60 persons from the rig. It is also quite risky to use the helicopter for the crew change for such long distances".

In addition to the opinion above, it is worth noting that recently there has been a surge of criticizing talks about helicopter crew changes in the offshore oil and gas industry to be taken into account when planning offshore logistics operations[63].

Onshore operations and facilities:

The "Songa Enabler" received all supplies from the Polarbase, located in Hammerfest. This supply base is built on a concept "A one stop shop" and is the closest to the offshore projects in the Norwegian Barents Sea.

As told by the interviewee of Norwegian oil company #1 about their experience during the drilling campaign of summer 2017:

"As we planned, and it was agreed with the supply base, the vessels should be uploaded and loaded again for the next voyage within 8 hours. However, our vessels spent more time - on average, 16-18 hours and up to 20 hours. Sometimes it was due to the opening hours of the supply base. Due to long distances, we could not predict the vessel speed all the time. If the vessel moored at the supply base in the middle of the night, it had to wait until 7 o'clock when the supply base is opened again. It was very often discussed that the supply base should be open 24 hours to utilize

[62] Available at: https://www.Equinor.com/en/what-we-do/responsible-drilling-in-the-barents-sea.html#

[63] A good example of such kind of criticizing talks is available on https://www.linkedin.com/pulse/time-stop-helicopter-crew-changes-offshore-industry-dennis-knox/

the vessel at the main cost without paying demurrage as well. It was not so critical for the drilling operations, we predicted this. However, we realized that if we pursued a long-term development of offshore northern projects, the proportion of cost-time in relation to the vessel demurrage would be a challenge".

In addition to the Polarbase in Hammerfest, it was organized also an extra receiving center in Kirkenes because of many different operations in Hammerfest. The extra center used also as an emergency response for medical evacuation.

3.1.3.3. Emergency preparedness logistics: SAR and oil spill response

One of the main challenges of this project was remoteness from the shore. As told by the interviewee of Norwegian oil company #1:

"To elaborate the logistics scheme and emergency preparedness for so remote area from the shore requires too long preparations and efforts – about 8 months before the start of the drilling operations. There were a lot of analysis during the preparations to the project around the Korpfjell activities. Some nuances may occur only during the project implementation. For example, for the previous project, we planned only 50% of the operations from Hammerfest according the rig's drilling schedule. At the same time, that project was delayed mainly because of start-up in Kirkenes with helicopters. It costed a lot of troubles for the helicopter supplier because of summer holidays for the pilots and so on. I think, they did not get so long holiday this summer".

Due to remoteness, the drilling operations at Korpfjell required to take additional measures to upgrade emergency preparedness.

During the drilling operations at the Korpfjell site, both companies – Equinor and ENI - jointly used two helicopters to develop different oil fields in the Norwegian Barents Sea: one SAR helicopter, and one transport helicopter, which can be converted to a SAR helicopter when needed. Both are Sikorsky S-92 helicopters.

As told by the interviewee of Norwegian oil company #1:

"Both helicopters are intended to contribute to enhanced safety offshore in the Barents Sea. This contributes to flexibility and good utilization of capacity, as well as long-term planning for the supplier. The SAR helicopter is equipped with the newly developed NVG (Night Vision Goggles) technology, as well as other search technology, which significantly enhances its rescue capability, especially in SAR operations in the dark. These two helicopters are intended to be used also for the Johan Castberg field (Equinor-ENI-Petoro), pending an investment decision by the

end of 2017, as well as for drilling operations on the Snøhvit field in September 2018".

At the Korpfjell location, there were two NOFO recovery systems for both winter and summer conditions. As the Korpfjell area is located near the polar front, there is a relatively high probability of fog in the summer and autumn. This may impose restrictions on some methods of mapping and monitoring an oil spill under one oil spill action and thus the effectiveness of the action. To compensate for this, Equinor adds to a NOFO system beyond the estimated need for resources in barriers 1 and 2. Therefore, a need for 3 NOFO systems was defined for the Korpfjell location, according to Equinor Contingency Analysis for exploration well #7435/12-1 at the Korpfjell[64].

According to the interviewee of Norwegian oil company #1:

"We planned for fog conditions at Korpfjell. The helicopter could not be used in this case. We had a solution to transport personnel by vessels. In addition, we had a basket at the rig for transport personnel from the rig into the vessel. We could use the stand-by supply vessel for the evacuation of the personnel".

Since the Korpfjell's exploration well had a long distance to today's location of NOFO's oil spill resources, Equinor planned an enhanced preparedness solution for this well. The third system included "Esvagt Aurora" vessel from the Goliat project, which was at a distance of 293 nm from the "Songa Enabler" rig. The response time for this vessel was defined 26 hours.

As told by the interviewee of Norwegian oil company #1:

"We have a general requirement that the first recovery system should be in the sea within 5 hours, including alarm system, pumps, the vessel to control the lens. However, in the Barents Sea the requirement was different, and the first recovery system should be in the sea within 2 hours to start the operations and the fully developed barrier within 36 hours. At the same time, if an oil spill happened, it took many days to eliminate the negative effect of an oil spill".

To optimize the effort on oil spill response, the emergency system included also oil detecting radar, infrared camera and possibility of downlinking images taken from helicopters. Satellite radar was included as a capacity for both detection and mapping through download of daily radar images. During an emergency operation, one can be download pictures two times per

[64] Available on http://www.miljodirektoratet.no/Global/dokumenter/horinger/Petroleum/Beredskapsanalyse%20for%20letebr%C3%B8nn%207435-12-1%20Korpfjell%20-%20Equinor%20ASA.pdf?epslanguage=no

day. NOFO had access to aerostat (Ocean Eye), which can be used to get an overview of oil at an action.

According to the interviewee of Norwegian oil company #1:

"The analysis for the Korpfjell well showed that there was no possibility for oil spills to reach the shore – too far away for any oil spill. The expected potential dispersion of oil on the ocean varies from well to well. For Korpfjell it is 120 km. The oil spill preparedness was specified in such a way that the most of oil would be recovered before it reached the shore. It also concerned the island of Hopen in the Svalbard archipelago, which is the closest land area to Korpfjell, 410 km away. We had also an extra capacity – tank boat capacity for having oil spill operations. There was also an agreement between Norwegian and Russian authorities in case of oil spill recovery operations crossed the Russian border".

Sharing the experience, the interviewee of Norwegian oil company #1 noted:

"It was the first and positive experience of sharing the SAR helicopter with ENI and the Goliat's vessel in the case of possible oil spills".

3.1.4. Case 4. Wisting project in the North-West Barents Sea.

3.1.4.1. Field location and natural conditions

General info:

The Wisting oil field is the northernmost oil field in Norway. The area in this license consists of parts of block 7324/7 and block 7324/8. The Wisting oil was discovered in September 2013 during the drilling of the Wisting Central exploration well 7324/8-1. The license PL537 is owned by OMV (Norge) AS (as operator has 25% share), Petoro (20%), Idemitsu (20%), Tullow (20%) and Equinor (15%).

The Wisting field area has been divided into six sections: Wisting Central East, Wisting Central West, Wisting Central South, Hanssen, Hassel, and Bjaaland. Exploration has confirmed hydrocarbons in the Wisting Central East and Hanssen segments.

The Wisting oil field awarded the production license PL537 in Q2, 2009. 3D seismic shot was carried out in 2009. The prospect was defined in Q4, 2010. Six wells at Wisting oil field were drilled:

- 2 wells in Q3/Q4 2013;
- 1 well in Q2 2014;

- 1 well in Q2 2015;
- 1 well in Q1/Q2 2016;
- 1 well in Q3, 2017.

The Wisting Alternative well (7324/7-1S) was drilled in October 2013 following the discovery of Wisting. The well was drilled to a depth of 2,452m by the Leiv Eiriksson semi-submersible rig to prove reserves in the Middle Triassic Kobbe formation.

The discovery contains reserves in a shallow reservoir located 250m below the seabed. The field is estimated to contain between 200 million and 500 million barrels of oil equivalent.

"OMV is very satisfied with the well test results, which are promising. This well is an important milestone towards a future field development on Wisting" -said Johann Pleininger, OMV Executive Board member responsible for Upstream[65].

During the period of January - March 2016, OMV successfully completed the drilling and testing of the Wisting Central II appraisal well. This well was the first horizontal appraisal well in the Barents Sea and set a new drilling record. It is the shallowest horizontal offshore well drilled from a floating drilling facility in the Norwegian Barents Sea. The well was spudded on January 15, 2016, by the semisubmersible rig Transocean Spitsbergen. The well test was finalized at the end of March 2016.

The drilling operation of Wisting Central III was carried out in August 2017.

Location:

The Wisting Central III well is located in the northern part of the Barents Sea, about 315 km (166 nautical miles) north of Hammerfest, several 100 kilometers away from any permanent ice and around 180 kilometers away from the nature reserve Bjørnøya (Bear Island). The water depth is 394.5m. The total well length is 2,354 meters and the horizontal section measures 1,402 meters. Advanced data collection and geo-steering was conducted through the entire horizontal phase.

[65] Available at:
https://www.omv.com/portal/

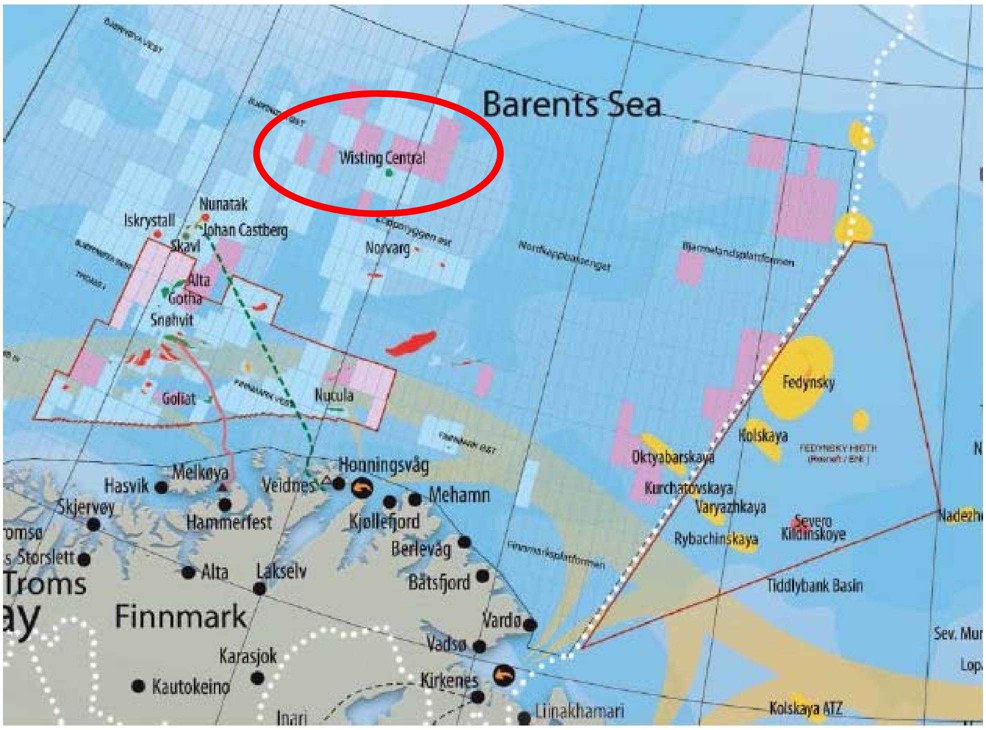

Figure 39. The location of Wisting oil field in the Norwegian Barents Sea (Source: miljodirektoratet.no)

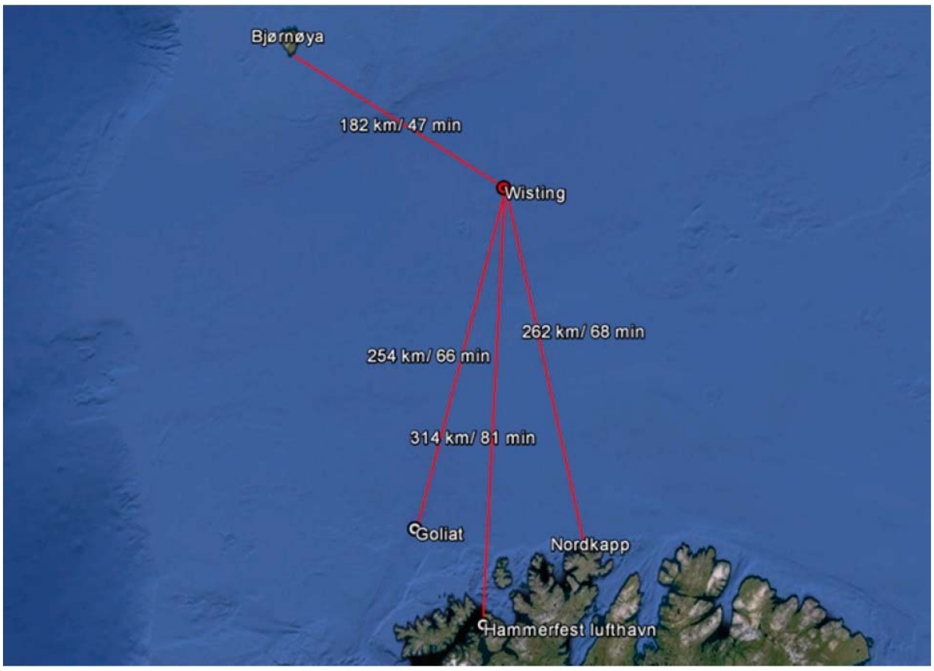

Figure 40. The distances from the Wisting oil field (Source: miljodirektoratet.no)

3.1.4.2. Field logistics: offshore/onshore infrastructure

Logistics challenges are primarily due to the remote geographical location of the well in the northern-most area with no previous drilling history. The distance from the supply base in Hammerfest is 315 km. There is low density of resources in the area.

During OMV's drilling operations in August 2017 the favorable weather conditions was experienced. The location reported about 12 hours of day light, average daily temperature of a few degrees' centigrade minus, low to medium wind speeds and wave heights.

Figure 41. The Global Maritime rig at the Wisting Central III site (Source: Island Innovator).

The rig was a Global Maritime GM4000 type, delivered by the COSCO shipyard in China in 2012. It is owned by Island Drilling Company, AS and operated by Odfjell Drilling. It is fitted with accommodation areas with one-man cabins for a 120-person crew. It was issued with an Acknowledgement of Compliance (AoC) by the Petroleum Safety Authority in August 2013.

Four vessels were engaged in the drilling operations in August 2017, presented in Table #3). These vessels are also fully equipped to ensure an immediate oil spill response in line with the strict local laws and regulations[66].

Table 3. ***Vessels engaged in the drilling operations of Wisting Central III in August 2017.***

Vessel	Ice class	Characteristics	Additional equipment	Owner	Built	Flag
"North Cruys"	ICE-1B Icebreaker, DnV +1A1	Platform supply vessel	OIL-REC NOFO2009, Oil- and Ice-radar, Winterized, Rescue 300 evacuees	GulfMark Rederi AS	2014 – Simek, Norway	Norway
"North Barents"	ICE-1B Icebreaker, DnV +1A1	Platform supply vessel	OIL-REC NOFO2009, Oil- and Ice –radar, Winterized, Rescue 300 evacuees	GulfMark Rederi AS	2013 – Skipsteknisk AS, Norway	Norway
"KL Sandefjord"	DnV +1A1	AHTS	ROV hangar & ODIM LARS system for underwater search operations; Hospital 1	"K" Line Offshore, AS	2011 – STX Norway Offshore	Norway
"KL Saltfjord"	DnV +1A1	AHTS	ROV hangar & ODIM LARS system for underwater search operations; Hospital 1	"K" Line Offshore, AS	2011 – STX Norway Langsten	Norway

<u>Onshore operations and facilities:</u>

[66] Available at https://www.omv.com/portal/01/com/omv/OMV_Group/upstream/norway/activities_in_barents_sea

The Global Maritime rig was supplied during the drilling operations from the ASCO supply base, located in Hammerfest.

3.1.4.3. Emergency preparedness logistics: SAR and oil spill response

Emergency preparedness is mostly challenged by the following factors:

- Environmentally sensitive area with harsh weather conditions and icing possibility: long periods of dense fog expected;
- Limited offset well data available;
- Unexplored area for drilling activity;
- Extremely shallow reservoir requiring enhanced focus on well control;
- Logistical challenges due to geographical location;
- Remote location and low density of resources in the area: medevac to Tromsø hospital takes up to 4 hours or more;
- Evacuation solution independent of helicopters.

These factors require increased focus and extended amount of efforts invested into securing safe operations. A stand by vessel with capability to operate in harsh weather is the primary resource to ensure emergency preparedness with telemedicine and two nurses on board (Krainer, 2015).

In case of an oil spill, extensive measures are required:

- Spill detection within one hour;
- SECurus detection system (radar plus IR);
- NOFO vessel at location;
- Full barrier I and II in place within 24 hours.

3.2. The Russian Arctic fields

3.2.1. Case 5. The Prirazlomnaya platform (the Pechora Sea)

3.2.1.1. Field location and natural conditions

General info:

The first and thus far only oil and gas project to be carried out on the Russian Arctic shelf is the development of the Prirazlomnoye field, which was discovered in the Pechora Sea in 1989. The field has estimated reserves of 72 million tons of oil. GazpromNeft-Shelf, LLC[67] holds the license for its development. The single stationary Prirazlomnaya platform, which has become the first Arctic-class ice-resistant oil platform in the world, was delivered to the oil field in August 2011. It has a design capacity of 6.5 million tons per year. Field reserves are estimated to about 72 million tons of oil and annual peak production of five million tons is planned for around year 2022.

Commercial drilling was planned to begin in early 2012, however, it was delayed at least until the Spring of 2013 due to "safety concerns". This is the first commercial offshore oil development in the Arctic. In 2014, the platform delivered around 2.2 million barrels of oil to the Port of Rotterdam. The oil produced by the Prirazlomnaya platform is called ARCO (Arctic Oil)[68]. The Prirazlomnaya platform produced the 10 millionth barrel of Russian North Arctic Oil in March 2016.

Location:

The Prirazlomnoye oilfield is located in the Pechora Sea, 60 km from the shore, at 19,2 m depth. Coordinates: 69°15′7″N 57°20′34″E.

Figure 42. The map of the Pechora Sea (Source: oilandgasonline.com)

[67] Gazprom Neft Shelf, LLC is GazpromNeft subsidiary founded in 2002 (the 1st author's note).

[68] ARCO is a new type of oil. It entered the global market in April 2014. ARCO is characterized by high density (about 910 kilograms per cubic meter), an increased concentration of sulfur and low paraffin content. ARCO serves as the basis for unique chemical products, which may be used in road-building, rubber tire manufacturing, space industry and pharmaceutics. Available on http://www.gazprom.com/about/production/projects/deposits/pnm/

Natural conditions:

The length of the Pechora Sea is about 300 km from West to East and 180 km from North to South having the surface area of approximately 81 000 km^2 and the overall water volume of 4380 km^3. The Sea is shallow since its average water depth is around 6 m, but it gradually increases toward the North reaching the maximum depth of 210 m.

The typical environment of the Pechora Sea is given in Table #4.

Table 4. ***Typical environmental conditions of the Pechora Sea (Gudmestad et. al., 1999).***

Parameters:	
Maximum wind gust, m/s	41 m/s
Minimum air temperature, °C	-48
Sign. wave height, m	6,2 (at 45 m water depth)
Currents velocity, m/s	1
Freezing up (average)	Nov. (Oct.) – Eastern part of the Sea
Clearing (average)	June
Average open water, days	110
Multi-year ice, %	-
Maximum level ice thickness, m	1,3
Rafted ice thickness, m	2,6 (twice level ice thickness)
First-year ridge thickness, m	12-18
Multi-year ridge thickness, m	-

An air temperature is below 0 °C for 230 days per year. Air temperature at the Prirazlomnaya platform varies from -46 °C in January to +26 °C in July-August. During the year the monthly average air temperature fluctuates from -17,4 °C in February to +6,5 °C in July, while the annual average value is about -5,1 °C.

In the summer season, a mean value of wind speed is about 6 m/s. During a storm, in the same season the speed can reach 20 m/s with duration of 6 hours in average and 36 hours at maximum. Even 30 m/s is possible with the maximum duration of 6 hours.

Extreme waves may reach up to 11.5 m at water depth 20-30 meters in October-November (Mischenko, 1996). It means that during the storm season there is a dangerous situation for supply vessels carrying out marine operations in the open sea. The average parameters of 10-100 year wave in the region are the following (Novikov, 2014):

- wave height – 3,2-4,7 m;
- wave length – 110-154 m;
- wave period – 8,6-10,5 s.

Ice conditions:

The sea is free of ice during about 110 days per year, but in the region of the field, the ice-free period can vary from 3 to 7 month (Novikov, 2014). Ice in the sea mainly has local origin, rarely accompanied with ice coming from the Kara Sea because of ice exchange between the seas. The first year ice is one of the characteristics of the Pechora Sea (Gudmestad et al., 1999). Ice covers the sea in winter period and melts away in the summer. The ice period lasts from the end of October until the end of July/early August (Mironov et al., 1994). Ice conditions of the western part of the Pechora Sea are milder than in the eastern part. The most extensive ice cover period is observed in March-April, when the whole sea surface is covered with ice (Spichkin and Egorov, 1995).

The thickness of level ice starts increasing in winter following the period of ice extension and reaches the maximum value, which is approximately 1.3 m in spring or beginning of summer. The extreme thickness is about 1.6 m. The thickness of rafted ice in the sea can be up to 2.5-3 m thick. In February, the sea surface coverage by hummocks can reach 60 to 80%, in April the hummocks can cover entire sea surface (Gudmestad, 1999).

Based on the data presented in the Pechora Sea Environment (Bauch et al., 2005), ice parameters for the Pechora Sea are provided in Table #5.

Table 5. ***Ice parameters in the Pechora Sea (Bauch et al., 2005)***

Ice Parameters	Early dates	Average dates	Late dates
1. Beginning of ice freeze-up	25.10	18.11	23.12
2. Fast freeze-up	23.12	22.02	11.04
3. Beginning of fast ice break-up	05.04	23.05	07.07
4. Total disappearance of ice cover	10.04	19.05	30.08
5. Duration of ice-covered season	131	213	272

Some characteristics of fast and drift ices are shown in Table #6 (Bauch et al., 2005).

Table 6. ***Parameters of fast and drift ices in the Pechora Sea (Bauch et al., 2005)***

Fast ice	
Extent, km	3-15
Average thickness, cm	110
Drift ice	
Thickness, cm:	
Average	80
Maximum	145
Size of ice fields, km:	
Average	1,4
Maximum	17,5
Continuity, units	10
Hummocks, %	60-90

3.2.1.2. Field logistics: offshore/onshore infrastructure

Offshore facilities and sea supplies:

The Prirazlomnaya is an offshore ice-resistant oil-producing stationary platform, built specifically for the development of the Prirazlomnoye oil field. The platform has been used for all production operations, namely well drilling, oil extraction, storage, treatment and offloading.

The platform's residential module is designed to accommodate up to 200 people, all year round. Due to the depth of the sea (19.2 meters), the facility — at 126 m^2 the size of two football fields, and weighing 500,000 tons — has been installed directly onto the seabed and reinforced with a protective 45,000 cubic-meter-plus stone berm (weighing 120,000 tons) ensuring the well cluster has no direct contact with the water.

The towing operation of the Prirazlomnaya platform into the Pechora sea started in August 2011 from the shipyard of the shipbuilding plant in Murmansk (See Figure 43).

The following vessels were engaged in the towing operation:

- Icebreaker "Vladislav Strizhov";
- Transport and towing vessels - "Kapitan Martyshkin", "Neptun" and "Eems";
- AHTS – "Neftegaz-57", "Neftegaz-61", "Pasvik";
- Russian coast guard vessel "Zapolyarye".

The towing operation lasted about two weeks. The length of the itinerary was 1,200 km.

Figure 43. The towing operation of the Prirazlomnaya platform in August 2011
(Source: by the 1st author based on Gazpromneft data)

All wells in operation on the platform are horizontal wells. A total 32 wells are expected to be drilled by 2023 — 19 production wells, 12 injection wells, and one absorption well. Eleven directional wells will run to depths of more than 6,000 meters, with horizontal sections of up to 1,000 meters and horizontal displacement of up to 4,000 meters.

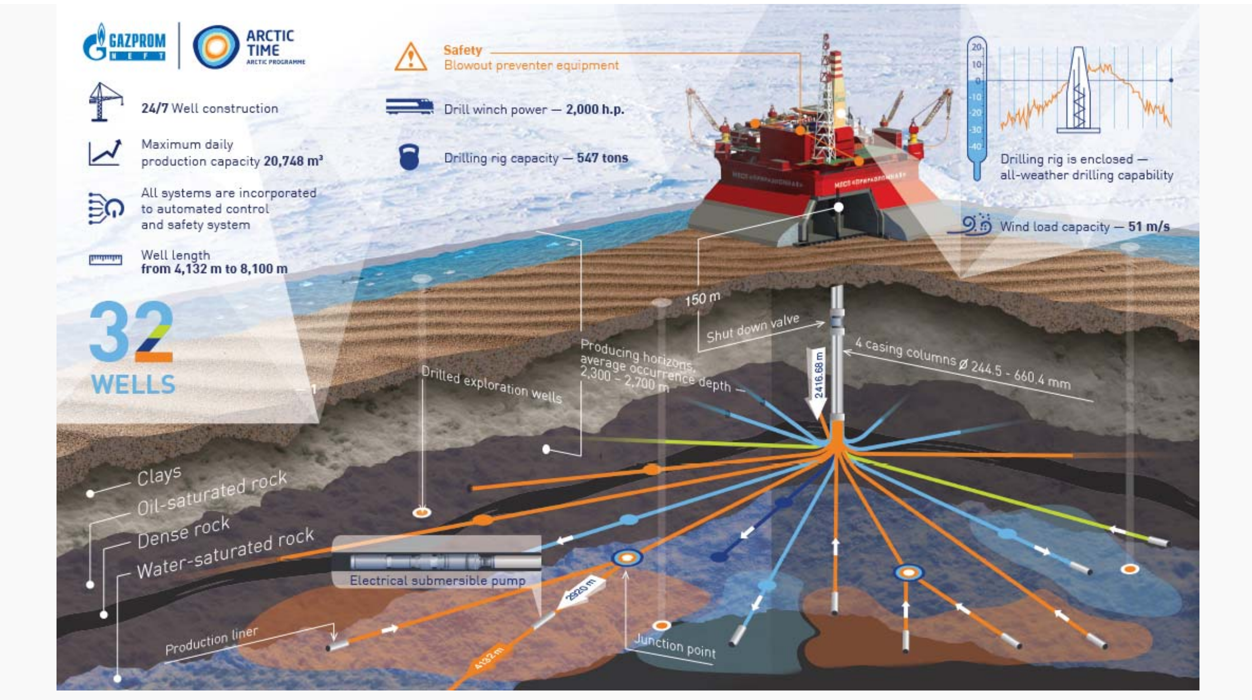

Figure 44. Drilling operations at the Prirazlomanya platform (Source: Gazprom Neft).

The wellheads of all wells to be drilled at the field are located within the platform, while its foundation serves as a buffer zone between the well and the open sea. In addition, a two-tier protection system - an emergency shutdown valve (ESDV) was installed at the wells to prevent blowouts of oil or gas. The offloading line used for transferring oil to tankers is provided with an emergency shutdown system that can be activated instantly. The round-the-clock monitoring of the Prirazlomnaya platform is ensured through a special system with over 60 detectors tracing the changes in its operation.

The Prirazlomnaya platform's needs:

To estimate the scale of operations, it is worth taking into account that the construction of 32 wells has been planned, according to the Prirazlomnoye field development project. A large quantity of materials and equipment is not the major part of the cargo traffic from the onshore base in Murmansk to the platform installed in the Pechora Sea. For example, in 2015 the total cargo volume was about 100 thousand tons. That amount included almost 30 thousand tons of drinking water and approximately 25 thousand tons of diesel fuel that were delivered to the Prirazlomnaya platform. At the same time, approximately 12 thousand tons of cuttings were transported from the platform to the shore in 2015 because the Prirazlomnaya platform operation principle envisages zero discharges.

The volume of oil to be transported from the Prirazlomnaya platform is to about 2 million tons in 2016. After 2020, when the field reaches the planned peak production performance, this figure will increase to 5 million tons. All operations necessary for the preparation, storage and shipment of crude oil are carried out directly on the offshore ice-resistant fixed platform.

Figure 45 illustrates the general logistics scheme for servicing the Prirazlomnaya platform, which includes the sea route between the platform and the supply base/oil terminal in the Murmansk port, as well as air routes for the transportation of rotating personnel and contractors' employees by chartered AN-24 aircrafts and MI-8 AMT helicopters: Arkhangelsk or Naryan-May – Varandey airport – Prirazlomnaya platform.

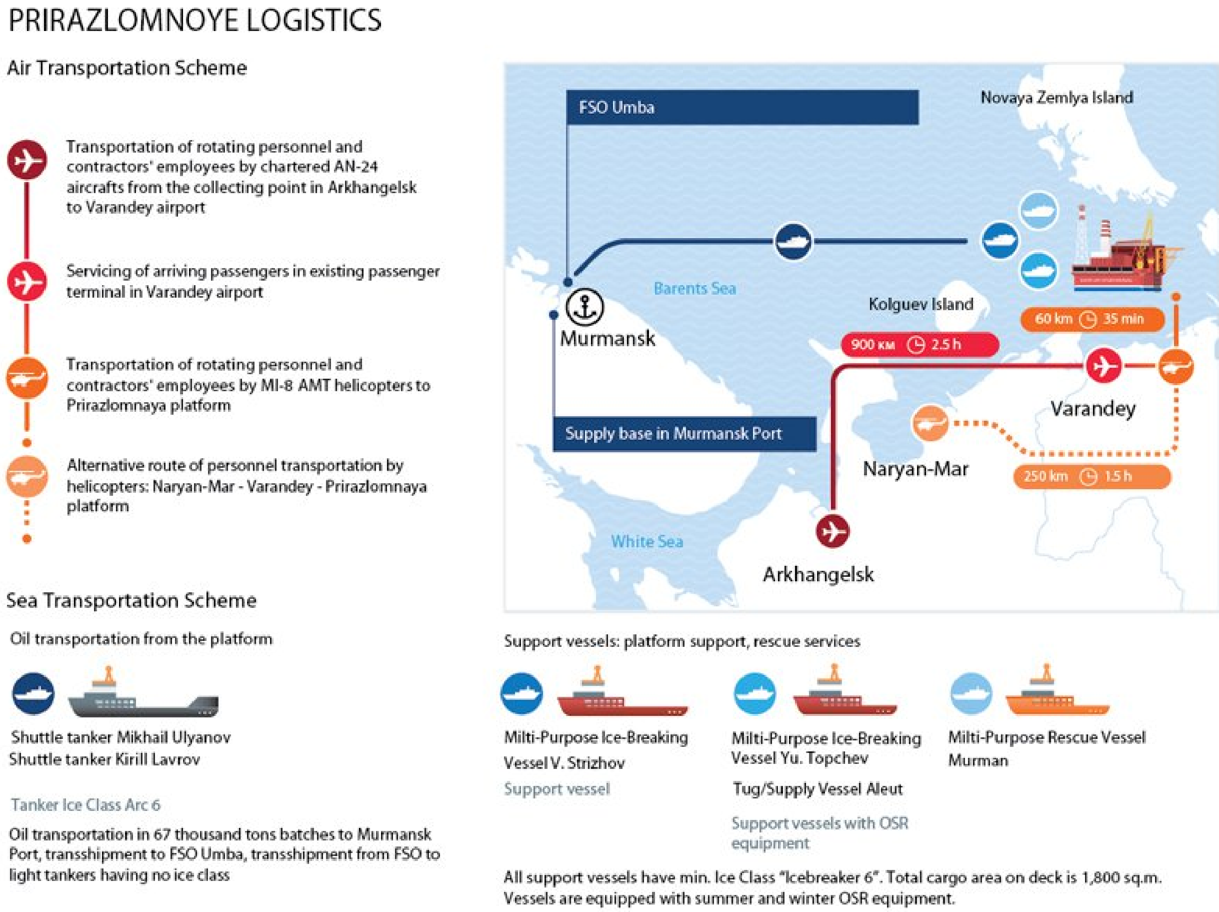

Figure 45. The general logistics scheme for servicing the Prirazlomnaya platform (Source: Gazprom Neft & Sibirskaya Neft Magazine).

<u>Onshore operations and facilities:</u>

To manage the production and delivery of personnel and cargo, a developed coastal infrastructure was created: a supply base in Murmansk and a storage terminal on Varandey Island.

The *onshore supply base* is located on the Kola Bay coast near Murmansk port, 980 km away from the platform. This is one of the main challenges for ensuring regular support of the Prirazlomnaya platform according to Oleg Sokolov, Deputy Head of Transportation Support Department in GazpromNeft-Shelf:

"*We work in harsh weather and ice conditions. Moreover, the platform is located far from the onshore supply base*".[69]

[69] Available on https://rogtecmagazine.com/gazprom-neft-arctic-routes2/

It is also worth emphasizing that the Prirazlomnaya platform is located in an area, which is ice-free for just 110 days a year.

The onshore supply base consists of several bases used for transportation of cargoes for the Prirazlomnaya platform, which are leased by GazpromNeft-Shelf from third parties. GazpromNeft-Snabzhenie, a specialized company, is responsible for delivery of materials, equipment and foodstuff from all parts of the country and from around the world as well as for onshore warehousing logistics. The company faces another challenge. Despite the availability of its own logistics operator, contractual relationships and interaction with several third parties, as well as working from several distant bases make supply support of the platform more complicate.

Therefore, GazpromNeft-Shelf is currently studying the possibility of constructing its own onshore supply base in Murmansk, which is able to serve this and other offshore projects for the company.

The storage terminal near Varandey settlement is presented on Figure 46.

Figure 46. The storage terminal near Varandey
(Source: http://russiatrek.org/blog/business/oil-production-on-the-shelf-in-the-russian-arctic/)

Gazprom Neft Shelf operates one more *transport terminal* in the Kola Bay for oil transshipment from the field to the European ports. Crude oil from the Prirazlomnaya platform is transported by the Panamax shuttle tankers, serving the field to the very large crude carrier Umba with 300,259 t dead weight, which is installed in a roadstead. Umba is used for oil storage, customs clearance and border control. After all formalities are completed, the oil is loaded onto the end-user’s tankers. This scheme allows oil tankers to reduce the number of round trips considerably – from 3,500 to 1,070 nm per trip and, therefore, increase the frequency of shipments while not increasing the number of the tankers. Moreover, the transportation terminal allows the buyers to use standard non-ice class vessels for ARCO oil transportation. Only special sea going vessels capable of cutting their way through the ice up to 1.5 m thick are to be utilized to reach the ice-free Kola Bay from the Pechora Sea coast.

Maritime vessel availability:

The Prirazlomnaya platform is usually served by a fleet consisted of 3 supply vessels, 1 rescue (stand-by) vessel and 2 shuttle tankers. All vessels are capable of operating in the ice conditions (See Table #7).

Table 7. ***Vessels engaged in the Prirazlomnaya platform's activities.***

Vessel	Ice class	Characteristics	Additional equipment	Owner	Built	Flag
"Yury Topchev"	DNV Ice-15, 1A1	Multifunctional icebreaking supply vessel	Oil.rec., FiFi I, 85 survivors, DAT (-40)	Gazflot - subsidiary of Gazprom	2006 – Havyard Leirvik, Norway	Russia
"Vladislav Strizhov"	DNV Ice-15, 1A1	Multifunctional icebreaking supply vessel	Oil.rec., FiFi I, 85 survivors, DAT (-40)	Gazflot - subsidiary of Gazprom	2006 – Havyard Leirvik, Norway	Russia
"Aleut"	Icebreaker6, ARC5 (DnV Ice-10)	Supply vessel	DYNPOS-1, Winterized (-30), Oil.Rec., FiFi 3	FEMCO	2015 – Havyard Ship Technology AS, Norway	Russia
"Balder Viking"	DNV Ice-10, +1A1	AHTS	-	Viking Supply Ships	2000 – Havyard Leirvik, Norway	Sweden
"Murman"	Icebreaker6	Rescue vessel	Oil.Rec., DYNPOS-2, FiFi2, helidec	Rosmorrechflot	2015 - Nordic Yards, Wismar, Germany	Russia
"Mikhail Ulyanov"	RMRS +LU6, 1A Super	Panamax shuttle tanker (double-hulled)	Helicopter Landing Area	Sovcomflot	2010 - Admiralty Shipyards, St.Petersburg, Russia	Russia
"Kirill Lavrov"	RMRS +LU6, 1A Super	Panamax shuttle tanker (double-hulled)	Helicopter Landing Area	Sovcomflot	2010 - Admiralty Shipyards, St.Petersburg, Russia	Russia

"Murman" rescue vessel is constantly near the Prirazlomnaya platform and responsible for emergency preparedness.

It is worth noting that "Balder Viking" vessel takes part in supply operations during several winter seasons: 2013, 2015, 2018.

As told the interviewee of Norwegian shipping company #1:

"During several winter seasons we provided the vessel as extra for ice management. Actually, ice management at the Prirazlomnaya has been challenged because there are regular loading/offloading operations of oil tankers. These operations have been interrupted if there is ice drifting and/or ice rubble formation alongside the platform. This can delay the tanker operations. Once we provided our vessel because the icebreaker, which usually serves the platform, was on maintenance, docking additional tonnage."

Both "Yury Topchev" and "Vladislav Strizhov" multifunctional vessels have onboard additional equipment for oil spill recovery in ice conditions. Both supply vessels are interchangeable. It means that various special modules can be installed on any vessel and removed if the vessel is on the cargo trip.

In March 2016, GazpromNeft-Shelf extended its fleet for Prirazlomnoye field with a new tug/supply vessel "Aleut". This vessel was built specially for the Prirazlomnoye project and has been assumed to execute the entire range of supply functions as well as technological/ecological standby functions.

In future, however, Gazprom Neft-Shelf plans to enhance the company's fleet with additional icebreakers considering the production program, changes in the ice conditions and other factors. According to Oleg Sokolov, Deputy Head of Transportation Support Department in Gazprom Neft-Shelf: *"To estimate the need in supply vessels, we have planned cargo traffic up to 2038, taking into account the well commissioning schedule and available statistical data, calculated the required deck and cargo hold area and now have an aggregate but complete picture. The main cargo traffic is expected up to 2023. The fleet composition will be changed as necessary thereafter"*[70].

Figure 47. "Murman" rescue vessel and the oil tanker at the Prirazlomnaya platform (Source: Gazprom Neft).

Two reinforced, 70,000-tonne maximum-deadweight double-hulled ice-class oil tankers – "Mikhail Ulyanov" and "Kirill Lavrov" - have been commissioned specifically to work at Prirazlomnoye.

Offloading of oil from the platform's storage facilities onto tankers is undertaken with the use of two direct offloading CUPON systems. One of them is located in the southern part, while another one in the northeast (See Figure 48). In order to prevent any spills during pumping and offloading operations the offloading line is equipped with an emergency shutdown system, with a maximum seven-second response time.

[70] Available on https://rogtecmagazine.com/gazprom-neft-arctic-routes2/

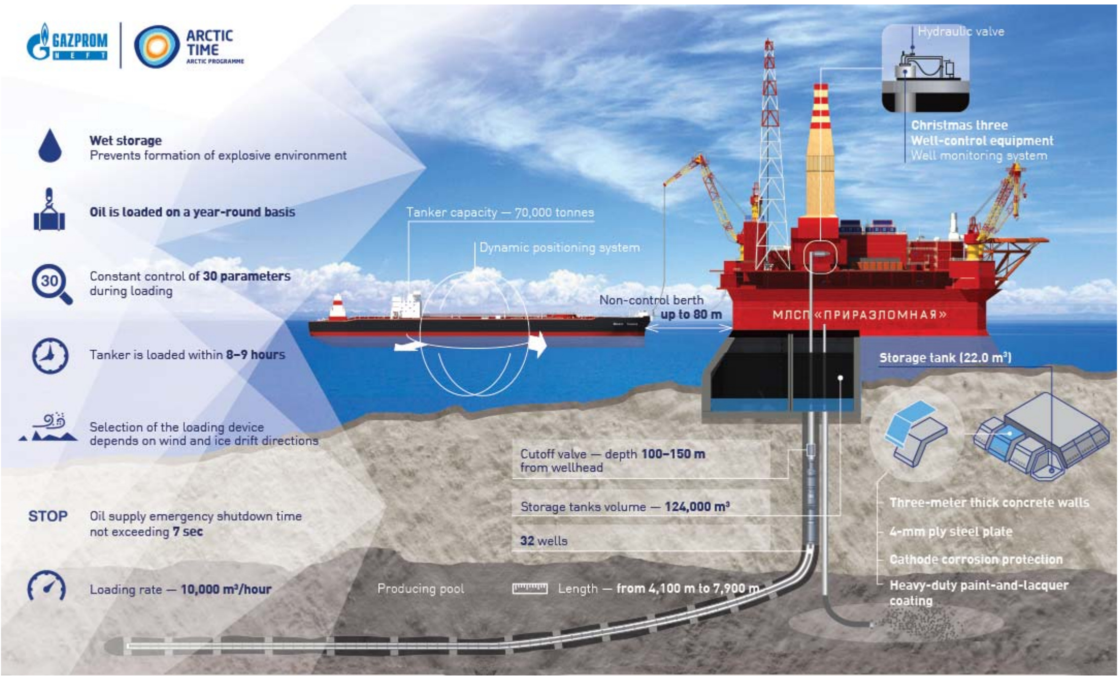

Figure 48. Oil production, storage and offloading (Source: GazpromNeft).

Offloading time is within 8-9 hours.

According to Oleg Sokolov, Deputy Head of Transportation Support Department in Gazprom Neft Shelf: *"The tankers are equipped with the unique oil transfer system. A dynamic positioning system allows the vessels to moor and pump oil from the Prirazlomnaya platform unloading module via the bow loading gear while staying away from the platform regardless of wind or waves"*.

At the same time, the climatic challenges have to be taken into account regardless of the start-of-the-art equipment. According to Konstantin Surikov, Deputy Head of the Fleet Operation Department in Gazprom Neft Shelf: *"Ice near the platform is drifting and we have to wait for the weather windows to pump the oil. These windows last for maximum six hours; then the current changes direction and ice squeezing against the tanker prevents it from holding the loading position. Thus, the vessel has to disconnect and retreat until the conditions are favorable again"*.[71]

As told by the interviewee of Russian oil company #3:

"Ice rubble formation is a real challenge for us because it is hard to remove, and it is formed again and again. The OSVs are not able to get close to the platform. The length of the cargo can be not so long as the width of the ice rubble. Lifting cargo from the vessels and uploading the vessels with waste and empty containers can be not difficult and risky".

[71] Available on https://rogtecmagazine.com/gazprom-neft-arctic-routes2/

Figure 49 presents oil transport routes of two Panamax shuttle tankers - “Mikhail Ulyanov” and “Kirill Lavrov” - from the platform to oil terminal, located in the Kola Bay for oil transshipment on end-users’ large crude carriers.

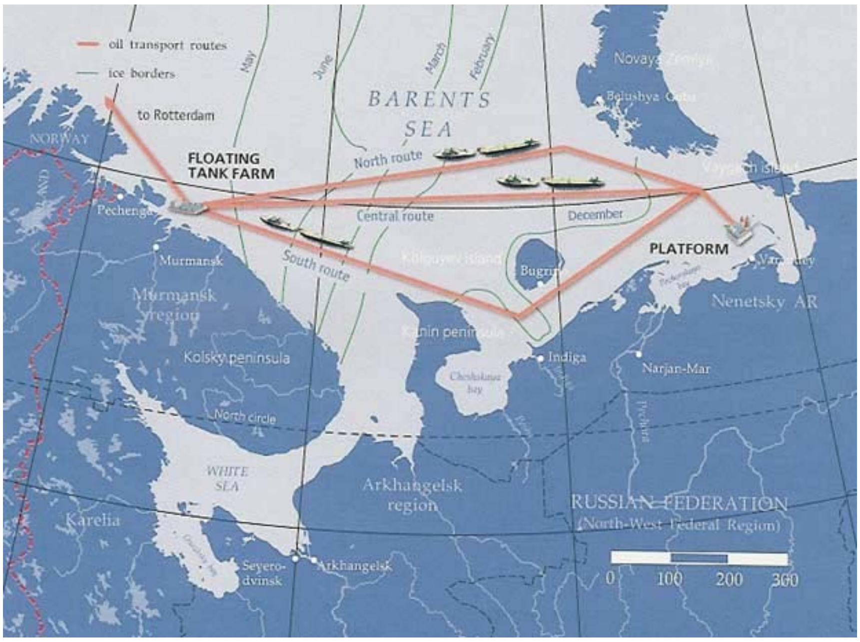

Figure 49. Oil transport routes form the platform to Murmansk oil terminal (Source: GazpromNeft).

Aviation Infrastructure:

Although the sea shipment is relatively inexpensive and allows shipment of huge cargo volumes, but it has one major drawback – it takes much time. In addition to the OSVs involved, aviation is the only option to resolve urgent transportation tasks on the shelf projects. However, there are also certain restrictions. For example, the length of the takeoff strip at the Varandey airport that bridges the platform with the mainland is 1.7 km, so the airport can only accommodate small aircrafts with the take-off weight up to 25 tons. For this reason, Prirazlomnaya platform personnel is transported from Arkhangelsk, which is the project air support base, using AN-24 turbo-prop aircrafts. The airplanes are reliable, but you can hardly call them state-of-the-art. The first AN-24 was commissioned back in 1959. Certainly, all aircrafts pass scheduled maintenance and repair and Gazprom Neft-Shelf conducts audits of the contractors’ airplanes, but nothing lasts forever, and the aircraft life will come to end in 2020.

There are no aircrafts to replace AN-24 and even if similar ones exist somewhere in the world, they are not certified in Russia. Therefore, Gazprom Neft-Shelf is currently in active search for the ways to resolve the upcoming problem. One of the options is to use an alternate airport in Naryan-Mar and transport people by helicopter to Varandey. However, this is more expensive as the number of helicopter flights will be three times as many as the airplane flights (currently 8-11).

Rotating personnel is transported from Varandey to the platform by helicopters. Special requirements are set to these helicopters as they fly over the sea. According to Alexander Voronin, Deputy Head of Logistics Department in Gazprom Neft-Shelf,

"There are four MI-8 AMT helicopters flying to the Prirazlomnaya platform. In 2015, Gazprom Neft-Shelf and Gazprom Avia completed the refurbishment of these four helicopters. We installed windows that can be broken outside, 16 chairs facing the direction of travel instead of benches along the sides, provided special cargo compartments for transportation of over-sized cargoes and installed ditching system"[72].

Today the company is constructing its own heliport in Varandey. The design passed state expert review and the plan is to commission the heliport in 2017-2018. According to Oleg Sokolov, Deputy Head of Transportation Support Department in Gazprom Neft-Shelf, *"Varandey airport is private owned by Lukoil company, and thereby, the expenses for airport use are high. Moreover, the importance of our own heliport in the region increases when we think of future Arctic shelf projects. Because even now the passenger traffic counts almost 10 thousand people"*.

Summing up the description of the logistics operations at the Prirazlomnaya platform:

It is worth noting that the main challenge has been to provide regular deliveries of supplies to the platform for up to 200 persons, as well as to ensure safe oil offloading and oil transportation, despite a long distance between the supply base and the platform, and the harsh weather conditions – waves, ice drifting, ice rubbly formation and wind, according to the interviewee of Russian oil company #3. Figure 50 presents the logistics scheme with distances and travel time.

[72] Available on https://rogtecmagazine.com/gazprom-neft-arctic-routes2/

Figure 50. The logistics scheme with distances and travel time (Source: GazpromNeft).

3.2.1.3. Emergency preparedness logistics: SAR and oil spill response

According to numerous Internet sources, Gazprom has for years been battered by accusations of insufficient attention to the potential environmental consequences of the project. The main concern is an oil spill in an environmentally fragile area with cold-water conditions amplifying the problem by making oil disperse more slowly than in warmer waters.

The project has been delayed several times, leading to increasing doubt about the platform's suitability for Arctic operations. Since 2004, seven delays have been announced, for example due to lack of environmental approval and deficiencies in drilling equipment (Sotnikova, 2012). Gazprom officials have retorted that the Prirazlomnaya platform could withstand a hit from a torpedo, and people drawing comparisons with the Macondo spill in the Gulf of Mexico have limited technical proficiency (Ramsdal, 2013).

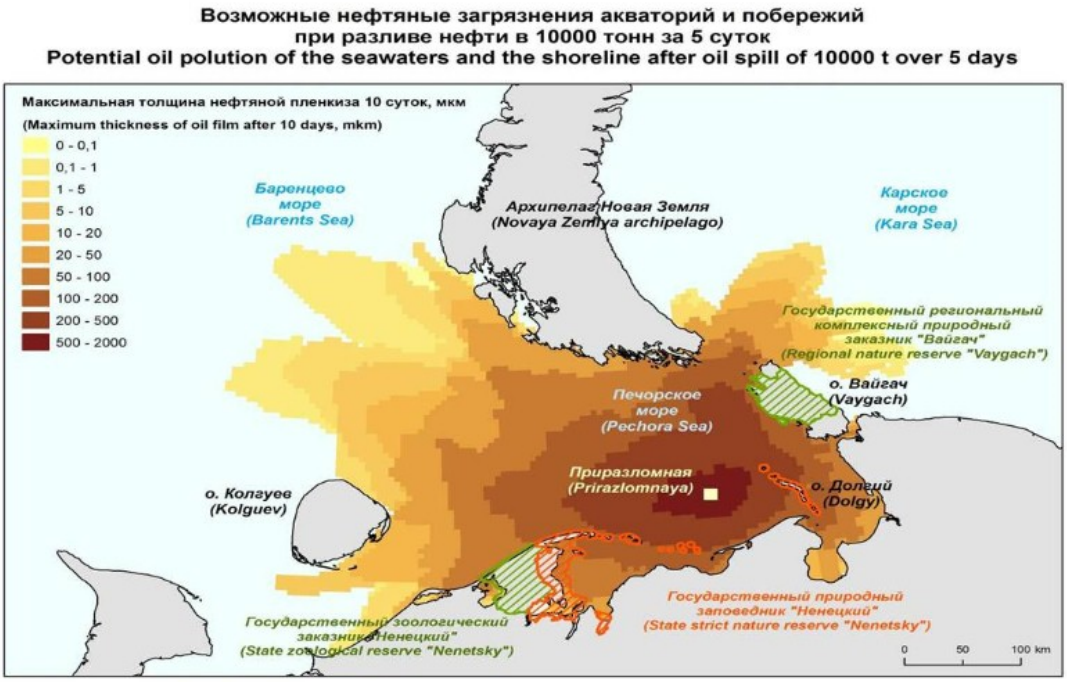

Figure 51. Potential oil pollution of the seawaters and the shoreline after oil spill of 10000 tons over 5 days (Source: Greenpeace).

The maximum size of possible oil spills from Prirazlomnoe are officially calculated to be 1,500 tons of oil for wells and 10,000 tons for oil tankers. This implies that the impacted area could reach 140,000 km2 (or four times the size of Lake Baikal) and affect more than 3,000 kilometers of shoreline. Figure 48 illustrates potential oil pollution of the seawaters and the shoreline after oil spill of 1,000 tons over 5 days. Three nature preserves are within the area of potential impact: the national park “Nenetsky” as well as the nature reserves Vaygach and Nenetsky (Starinskaya, 2012a).

A report commissioned by WWF and Greenpeace Russia in 2012 points out that with the equipment employed in the oil spill preparedness plan, only 20 per cent of an oil spill could be collected and no plan for saving the local fauna exists (Lunden & Fjaertoft, 2014).

There was developed a special oil spill response plan for cooperative and joint activities between supply vessels and other resources presented on Figure 52.

The oil spill response plan provides for permanent presence of rescue and salvage vessel “Murman” near the Prirazlomnaya platform. This role is performed also by multifunctional icebreaking supply vessels - “VladislavStrizhov” and “Yury Topchev”.

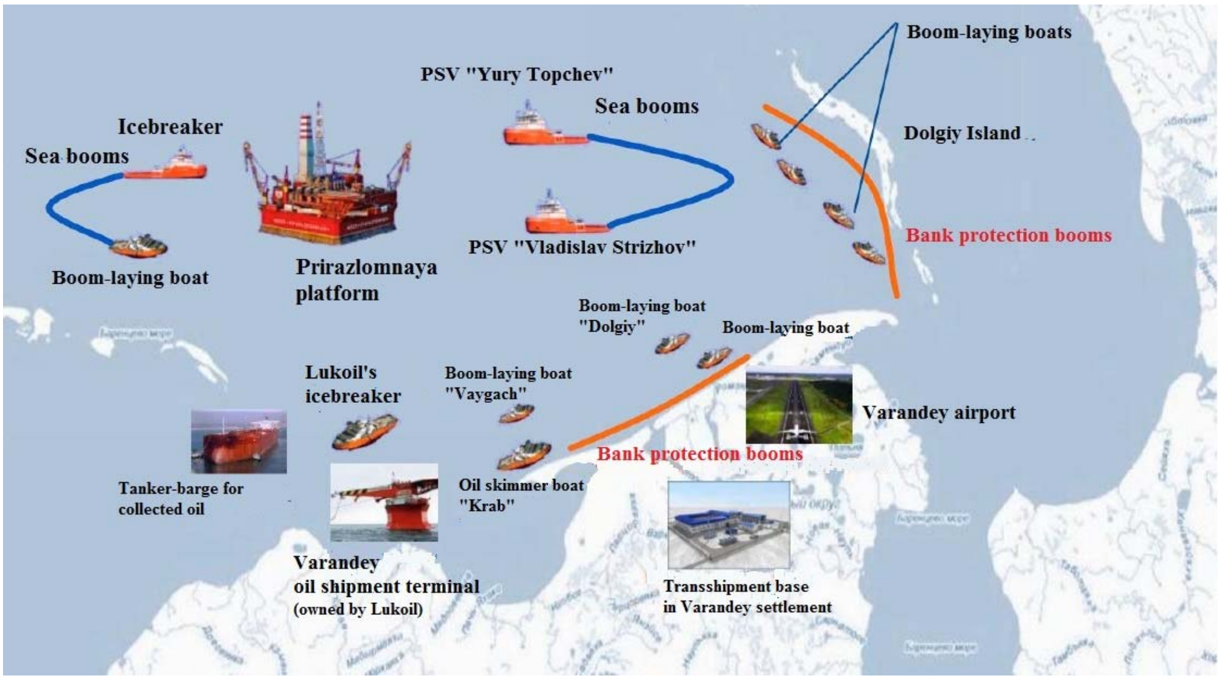

Figure 52. Allocation of supply vessels and other resources for cooperative and joint oil spill response around the Prirazlomnaya platform (Source: GazpromNeft).

The main oil spill response technologies are:

- In the open sea: a duty rescue and salvage vessel supported by a boom powerboat sets booms in order to localize the spill or trap a part of it; then a high capacity free floating offshore oleophilic skimmer collects the oil from the trap formed by the boom;
- In coastal waters: setting of protection or deflection booms and oil collection with low capacity oleophilic skimmers;
- In ice conditions: oil collection from ice-free areas with Arctic skimmer.

"Zero emissions" technology has been integrated into the platform to prevent the discharge of any production or drilling waste into the sea, with used drilling mud, slurry and other wastes, instead, re-injected directly into the strata through a special absorption well, or transported onshore for recycling. Process water is supplied via special fish-protection devices.

Table #8 provides the location of these technologies to be used in case of an oil spill[73].

[73] Available in WWF research report on https://new.wwf.ru/upload/iblock/c08/arctic_oil_spills_modeling_eng.pdf

Table 8. ***The type and location of the technologies to be used in case of oil spill near the Prirazlomnaya platform.***

Boom type	**Length, m**	**Total height, mm**	**Location**
Marine inflatable boom	1,200	1,500	Each supply vessel carries 400 m of booms, 400 m of booms, 400 m of booms are stored in a container at the platform
Permanent buoyancy port booms	2,000	1,000	Stored at the OSR base in Murmansk. In case of oil spill emergency, the booms are delivered to the spill site by a supply vessel within 23 days. Used in ice-free periods
Coast isolating booms	300	500	Stored at the OSR base in Murmansk. In case of oil spill emergency, the booms are delivered to the spill site by a supply vessel within 2-3 days. Used in ice-free periods.
Skimmer type	**Collection capacity, m3/h**	**Qty, pcs**	**Planned location**
Brush Minimax 10 (Lamor Company) for oil collection in hard-to-reach places	10	6	Varandey coastal base -3pcs; 1pc on each supply vessel; 1pc placed on the platform
Free floating offshore – for oil collection offshore	200	2	During ice-free period – onboard a supply vessel, in winter the skimmer is stored at the OSR base in Murmansk. If needed, the skimmer is delivered to the spill area by a supply vessel.
Arctic skimmer (oil collection in ice conditions)	70	2	In winter it is placed onboard a supply vessel. During ice-free period the skimmer is stored at the OSR base in Murmansk
Water-borne vehicles	**Characteristics**		**Package, application, location**
Supply vessel – 2 units	Deadweight 3,800 t; speed at 8.00 m draft – 15 knots; Ice1,5 m; snow 70cm – 2knots; Ice 0.8 m – 10knots		Year-round emergency and rescue readiness at the platform is ensured by multipurpose icebreaking supply vessels, each carrying 3 skimmers with power units (Minimax 10 & FFO skimmer (in ice-free period), Arctic skimmer (in ice period), and a set of floating booms (400m long). Function: boom deployment, oil collection activities, oil dredging. Each supply vessel also carries tanks for temporary storage of collected oil with total capacity of 1,000m3 and a dispersion medium application device
High-speed boom powerboat (onboard the supply vessel) – 2units	Length – 10m, draft – 1m		Delivery of coast-isolating and permanent buoyancy booms and their deployment for oil spill deviation and protection of peculiarly sensitive coasts. Located onboard a supply vessel
Work boat (Sever-7) – 2 units	Length 12.98 m, width 3.6m, draft 1.03m, speed 8knots, deadweight 2t		Personnel and equipment delivery to hard-to-reach coast areas, oil collection at shallow waters. Rented when necessary

To reduce noise impacts, helicopters delivering personnel to the platform fly over the sea at a height that will not disturb its inhabitants — i.e., not less than 500 meters. In addition, Prirazlomnaya has a specialist birdlife protection facility, covering a range of 3,000 meters. Broadcasting disturbing and annoying sounds, as well as authentic predator calls and man-made noises, it prevents birds from nesting and forming permanent flocks in the protected area.

Figure 53 illustrates oil spill response protection at the Prirazlomnaya. There were determined three levels of responsibility:

Level:	**Responsibility:**	**Possible reasons of oil spill accident:**
- Local level	- Platform crew	- Loading system accident
- Regional level	- Regional command post	- Loss of control of a well
- Federal level	- Rosmorrechflot	- Rupture of an oil tank
		- Accident at a tanker

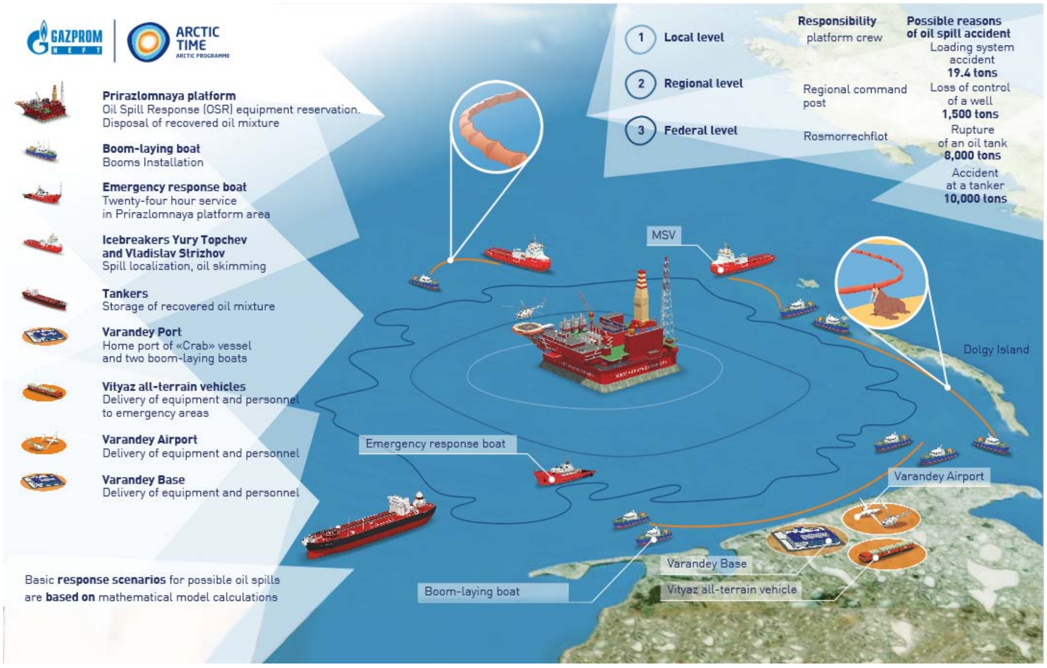

Figure 53. Oil spill response protection at the Prirazlomnaya (Source: GazpromNeft)

Accidents:

The first accident happened in the middle of October 2011: the evacuation ladder was blown off during a storm in the Pechora Sea. Information about the incident appeared in the media only in November 2011. According to one of the employees during that period, this incident embarrassed the platform's connection with OSVs and, in case of any emergencies, it would be very difficult to evacuate people from the platform. It eloquently illustrated the degree of "readiness" of the Prirazlomnaya platform for working in the harsh conditions of the Arctic seas[74].

[74] Available at: http://gp-russia.livejournal.com/1534144.html

3.2.2. Case 6. The Universitetskaya-1 well, the East-Prinovozemelsky field, later renamed the Victory field (the Kara Sea)

3.2.2.1. Field location and natural conditions

General info:

The Universitetskaya-1 well (later renamed the Victory field) is a vertical well drilled at the depth of over 2,000 meters in the East-Prinovozemelsky-1 license area, which is a gigantic undeveloped Arctic oil and gas field. It is located in the South Kara basin of the continental shelf of Russia, in the South Kara Sea between the Yamal Peninsula and Novaya Zemlya Island. The University-1 well in the Kara Sea is the northernmost well in the world

The operator was a joint venture called Karmorneftegaz, owned by Rosneft (51%) and ExxonMobil (49%). The drilling was completed in record-breaking time for 1.5 months – August-September 2014. It was initially expected that the drilling would continue for around two months, during the ice-free season that lasts from August through mid-October.

"According to the results, the resource base of the first hydrocarbons trap discovered through the drilling is estimated to hold 396 billion cubic meters of gas and over 130 million tons (730 million barrels) of crude oil", as reported by Head of Rosneft, Igor Sechin. *"This is light crude comparable to the Siberian Light blend, according to the initial tests. This is an outstanding result of the first exploratory drilling on a completely new offshore field"*, he added.

The new deposit was given a symbolic name "Pobeda" (means Victory) after the drilling operations were completed and the good results were received.

As told by the interviewee of Norwegian shipping company #1:

"The Kara Sea exploratory operations was a huge operation and the first one where we provided our services as a turn-key provider – in the combination of supplying anchor handling by our vessels and different tasks of ice management duties. It was a huge project! The contract for ice consultancy and ice management services valued only 60mln US Dollars, excluding the vessel contracts."

For the drilling operations, there was organized a united team of several partners like ExxonMobil, Nord Atlantic Drilling, Viking Ice Consultancy, Viking Supply Ships, Schlumberger, AARI, StormGeo, 123Logistics, KSAT, Halliburton, Weatherford, Baker, Trendsetter, FMC Technologies and others.

According to the interviewee of Norwegian shipping company #1, it matters that all suppliers put together into one project, work cohesively:

"It was the biggest campaign in the Arctic ever. One of the most important at the preparation stage is the selection of the right competent suppliers and right partners with a lot of

experience working in the particular area. It will be not a big failure or difficult to change a supplier when you start the operations. That was our responsibility and we paid a lot of attention to our choice. These operations were unique not only because of new experience in ice conditions, but also because a huge number of suppliers and partners from various fields were involved. Thus, that was part of the logistics strategy development to find a proper way to coordinate all their different activities."

Location:

The drilling operations took place on the Russian continental shelf Northwest in the Kara Sea, approximately at N 74°30' and E 064°. The well was drilled to a depth of 2,113 meters in open-water conditions, 250 km off the Russian coast and 50nm from the coast of Novaya Zemlya. The sea depth at the drilling site was 81 meters.

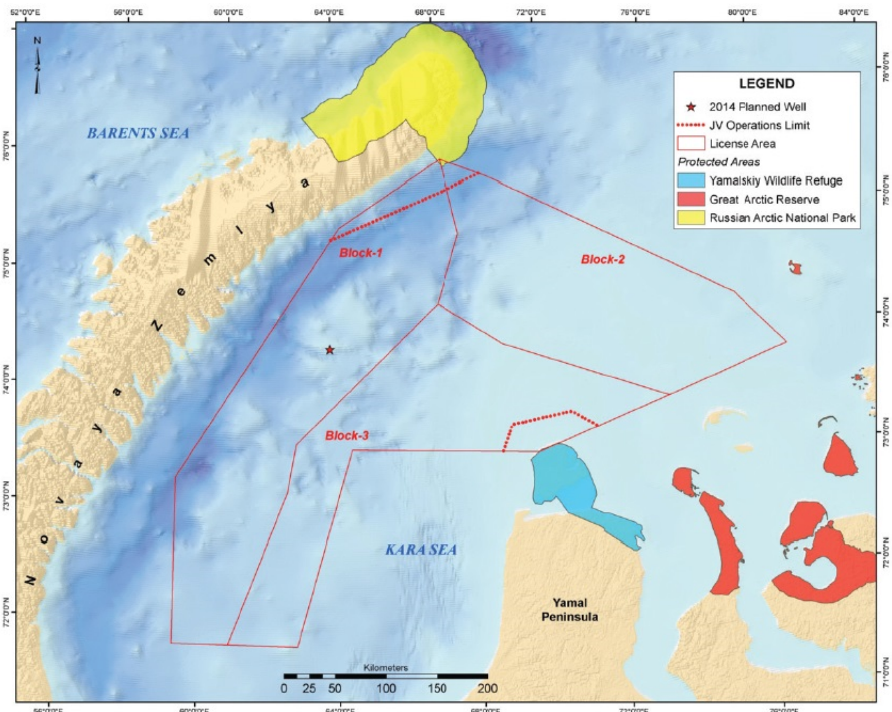

Figure 54. The location of the University-1 well in the Kara Sea (Source: ExxonMobil.com).

The Kara Sea has a special regulatory status. In contrast to the norms of navigation in the waters of the Barents Sea and the Pechora Sea, sailing and navigation in the Kara Sea is subject to a special maritime legislation of sailing in the water area of the Northern Sea Route (See Section 2.4.5.). Further, most of the area around Novaya Zemlya is highly restricted due to military zones and regulations. Even potential use as a place of refuge for vessels is prohibited, although this could be disputed according to international laws of the sea. During the 2014 season, some of the service vessels experienced a quite annoying situation when they had to change their course by demand of the naval ships between the drilling site and the Murmansk port. These factors serve as limiting factors for logistics preparations and planning of emergency preparedness.

<u>Natural conditions:</u>

The Kara Sea.

The Kara Sea is part of the Arctic Ocean north of Siberia. The Kara Sea, an extension of the Arctic Ocean, is located off the coastline of Siberia in far northwestern Russia. It is separated from the Barents Sea (in the west) by the Kara Strait and Novaya Zemlya Archipelago; and from the Laptev Sea (in the east) by the Taymyr Peninsula and Severnaya Zemlya (See Figure 55).

Figure 55. The map of the Kara Sea (Source: Worldatlas.com)

In the Kara Sea, the average depth of the sea is 111 m and the maximum depth 600 m. The sea is ice-bound for most of the year; the sea is generally navigable only during August – September season.

The Kara Sea is almost non-seismic. However, there were four events with source depths of 10 to 25 km and magnitudes up to 5 on the Richter scale, two of which occurred on the island of the October Revolution.

There is one main type of water mass in the Kara Sea: cold Arctic water (temperature <0 °C, salinity <35) from the north.

The air temperature is below 0 °C retained in the north of the Kara Sea 9-10 months, in the south - 7 - 8 months. The average January temperature is about -20 to -28 °C (minimum can reach -50 °C), July -6 to +1 °C (maximum can reach +16 °C).

The relative humidity is high throughout the year (80-85% in winter, 90- 95% in summer). Fogs at the sea are most frequent in July and August. The number of days with storms – is 1-2 month in the summer months and 6-7 in the winter. The greatest number of storms is observed in the western part of the sea.

The sea temperature defines ice extent and ice concentration. Ice ranges in thickness from 1.2 to 1.6 meters. the Kara Sea is subdivided into two large areas, the north-eastern and south-western, in which ice conditions are poorly related. In the winter, the entire Kara Sea is covered with close drifting ice with fast ice occupying large areas of the coastal areas. Its south-western part is covered by one-year ice of local origin with a predominant thickness up to 1.8 meters and young ice up to 0.3 m for 8-10 months a year, whereas summer it is usually completely ice free. Freeze-up of the south-western Kara Sea usually occurs in October, in the absence of residual ice. The north-eastern part is not completely free of drifting ice during the summer. In the winter, the north-eastern part is covered by perennial ice with a thickness of about 2.5 – 3.0 m. The fast ice is formed annually along all the continental and insular coasts of the Kara Sea. The Kara Sea is also occupied by icebergs, ice ridges and hummocks. The maximum-recorded values of the hummocks geometric characteristics are: the height of the above-water part is from 10 to 15 m, the keel depth is from 20 to 25 m. The icebergs are mainly concentrated near the northeastern coast of Novaya Zemlya.[75]

The Kara gate strait.

The Kara gate strait is the main shipping lane between the Barents and Kara seas, connecting the western part of the Russian Arctic and the Northern Sea Route. The 18 nautical miles strait has a minimum depth of 21 meters and shipping uses an established traffic separation scheme. Maximum fog and low visibility occur during July and August. In winter, the Kara Gate strait is covered with drift ice. The duration of the sailing season without icebreaker escort is 3 - 3.5 months.

Sanctions and further development:

A second drilling operation at the Universitetskaya-1 field was originally to be conducted in 2015. However, Rosneft and ExxonMobil stopped their Kara Sea drilling operations on October 10, 2014, due to sanctions imposed by the U.S. Treasury against Russia for its involvement in the

[75] Available on http://studbooks.net/1825318/geografiya/karskoe_more

Ukraine crisis[76] (See Section #2.4.7.). The original deadline for the companies to comply with the sanctions was September 26, 2014, but ExxonMobil gave more time to wind down its Arctic operations in a safe manner.

Rosneft had to postpone all activities in the Kara Sea *"to a later stage"*, as told by Russian Minister of Natural Resources Sergey Donskoy, - "*A key reason for the delays are western sanctions which are limiting access to necessary offshore technology"*[77]. According to Head of Rosneft, Igor Sechin, Rosneft plans to resume the drilling operations at Universitetskaya-1 field in the Kara Sea in 2019[78].

Then Karmorneftegaz company had to terminate the contract with Siem Offshore for lease of two service vessels: "Siem Topaz" and "Siem Amethyst", and one platform supply vessel "Siem Pilot", which were intended for exploration operations 2015 in the Kara Sea. Karmorneftegaz had to pay a big amount of fines to Siem Offshore[79].

The field exploratory activities-2014 in the Kara Sea required a lot of the Kara Sea studies, organized by Rosneft in partnership with the Arctic and Antarctic Research Institute, before the drilling operations at the Universitetskaya-1 well in 2014 and afterwards for further development of this field. These Arctic studies have been based on a detailed collection and a deep analysis of met-ocean data (wave, currents, sea level fluctuation, wind velocity, etc.), as well as ice-data for conceptual design of year-round oil and gas production facilities in the Kara Sea license blocks.

As told by the interviewee of Russian oil company #2:

"Our winter/summer expeditions in the Kara Sea and other Arctic Russian seas allow us increasing knowledge about the field conditions, acquiring experience in the field of ice management, improving the Kara Sea weather forecasts and… We assure that this knowledge in real ice conditions will allow us to evaluate logistics for shelf projects and find the most efficient logistics solutions, to ensure emergency preparedness of the offshore facilities and crews onboard both the platforms and service vessels. Our knowledge and experience in ice management will help to prevent any possible collisions with icebergs and to reduce the strength of drifting ice. We prefer to work with ice, but not to fight ice!"

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[76] The sanctions, established in 2014, have prevented all U.S. based oil companies from conducting operations related to the exportation of goods, services, or technology in support of exploration or production for Russian deep-water, Arctic offshore, or shale projects, which have the potential to produce oil, to five Russian energy companies – Gazprom, Gazprom Neft, Lukoil, Surgutneftegas, and Rosneft (the 1st author's note).

[77] For more information, see https://thebarentsobserver.com/en/industry/2015/11/drilling-kara-sea-put-ice

[78] Available on: https://thebarentsobserver.com/en/industry-and-energy/2017/04/russian-drilling-barents-sea-coming

[79] For more information, see http://www.yamalpro.ru/2014/12/02/rosneft-otkazalas-ot-norvezhskih-sudov-prednaznachennyih-dlya-razvedki-v-karskom-more/

There were organized 18 specific expeditions for today[80] in order to be able to manage and tow icebergs as a result. Here are some of them related particularly to the Kara Sea studies:

- The Kara-Summer-2013 in August 2013: experts spent 30 days at sea onboard the "Akademik Fyodorov" survey vessel. Rosneft used 12 vessels, three aircraft, air drones, submersibles, subsea and floating self-contained stations, satellite surveillance systems and other equipment for the Kara Sea studies.

- The Kara-Winter-2014 in April 2014: it was organized on board icebreaker "Yamal" and lasted 55 days to explore the glaciers at Novaya Zemlya, Severnaya Zemlya, New Siberian Islands and Franz Josef Land with a special focus on biological studies and environmental protection measures. In addition to "Yamal", Rosneft used satellites, a KA-32 helicopter, an unmanned air drone, an underwater camera, buoys and remotely operated vehicles Gnom with depth of submersion of up to 100 meters for the exploration of sea floor.

- The Kara-Summer-2014 in August 2014: it was organized onboard the "Akademik Tryoshnikov" scientific research vessel and lasted 57 days to explore the sea and ice conditions of several Rosneft license blocks in the Kara Sea, the Laptev Sea, the East Siberian Sea, and the Chukchee Sea. Experts installed 45 drifting buoys to track the movements of icebergs in the glacier areas of the northern island of Novaya Zemlya and the islands of the archipelago Severnaya Zemlya.

- The Kara-Winter-2015: it was organized on board icebreaker "Yamal" and lasted 55 days to explore specifically mechanical properties of ice (over 2 thousand of measurements on 35 ice stations), morphometric parameters of flat ice and hummock for calculation of load on designed engineering structures. More than 100 autonomous sensors were installed on icebergs and ice fields for measurement of parameters of drift and tracking of their coordinates.

Figure 56. One of ice stations during the Kara-Winter-2015 to explore mechanical properties of ice (Source: Rosneft).

[80] Available on https://www.newstube.ru/media/specialnyj-reportazh-kara-leto-2017

- The Kara-Summer-2015 in August 2015: it was organized onboard the ”Viktor Buinitsky” research vessel and lasted over 35 days to explore an area between the Kara Sea and the East Siberian Sea and then to assess the environmental impact in developing Rosneft's license blocks.
- The Kara-Summer-2016: it was organized to establish Rosneft's first scientific base in the Khatanga Gulf (See Section #3.2.6. of the report). In the Kara Sea, specialists performed a specific experimental work in ice management and changed for the first time in Russia the trajectory of iceberg drifts by external influence: 18 successful towages of icebergs, including a simultaneous towage of two icebergs, were performed. Icebreaker “Captain Dranitsin” towed the icebergs with a 90 and 180-degree turn of movement vs. their original trajectory.
- The Kara-Summer-2017: it was organized onboard the ”Novorossiysk” icebreaker (built 2016) and lasted over 40 days to perform eight experiments on hunting icebergs from oil platforms in the Kara Sea. 18 experiments were performed on physical impact on icebergs. For the first time, a controlled towing of the iceberg was carried out with the help of the “Novorossiysk” icebreaker at a distance of 50nm for one day (See Section #4.3. Ice management).

Figure 57. Towing of the iceberg (1.1 million tons by the «Novorossiysk icebreaker in 2017 (Source: **Rosneft)**

Rosneft plans to resume the drilling operations in the East-Prinovozemelsky-1 license area in 2019. Initially, the construction of at least 15 offshore platforms was planned for the development of the Kara Sea fields.

3.2.2.2. *Field logistics: offshore/onshore infrastructure*

The only well drilled on the Universitetskaya structure during the ice-free drilling season in August demanded implementation of a powerful shipping support system including rescue and transportation vessels, icebreakers, floating hotels all worked in the Kara Sea. The drilling activity required long preparations and complex pre-lay logistics operations related mainly to the rig towing, icebreaker participation, service vessel support and ice management.

As told by the interviewee of Russian oil company #2, they faced a lot of challenges when starting the preparation to the Kara Sea drilling campaign (presented in Table #9):

Table 9. ***Main challenges of the Arctic shelf (according to the interviewee of Russian oil company #2)***

1. Complexity of offshore drilling unit selection:	**2. Drilling campaigns planning:**	**3. Support and follow up of drilling campaigns:**
- The offered duration of its lease (operation in arctic lasts up to 6 months), while normally lease duration offered by contractors is minimum 2 years period.	- the availability of all the necessary equipment, materials and spare parts in order before starting of drilling operation, including extra drilling pipes and other necessary equipment to achieve the planned well depth and avoid downtime caused by missing of spares	- Estimation of the required number of supply vessels and determine vessels types and needed technical and operational characteristics to effectively support operations in Arctic conditions
- Adequate design and technical specifications for Arctic environment operation.	- Short ice-free drilling time window (from 2.5 to 5 months)	- Remoteness from the coastline and lack of infrastructure in the region.
- Adequate design and technical specifications for emergency preparedness and environmental protection (zero discharges requirement)	- Planning and preparation of the drilling operations, permissions to conduct operations at least 1.5 years before the planned drilling start	- Limited available infrastructure for the drilling waste disposal.
- Drilling unit crew should have the experience in drilling operations in arctic conditions	- the necessity of the upgrading/ winterization of drilling and supporting drilling equipment to adapt it for operation in harsh Arctic conditions	
	- The organization of the required onshore facilities in advance (including the quay facilities) for effective operations support and rig supply during the drilling operation.	
	- the required onshore medical support in advance, required in the situation of an emergency offshore personnel evacuation	

Main challenge of marine operation in the Kara Sea is the unpredictable ice and weather conditions. Ice masses movements are to be constantly monitored from both on board the vessels and the onshore control center or the office in order to track changes and coordinate all activities with other partners involved. The interviewee of Russian oil company #2 shared experience:

"Once we faced with a situation when during seismic operation the ice masses unexpected arrived from the north, while that was not typical for that year season, and happens extremely seldom according to our previous experience. As a result, we could not complete the part of operation by end of season and had to correct our working program and postpone it to the following ice-free season".

Maritime vessel availability:

The support fleet for the West Alfa rig consisted of 15 vessels, including a dedicated ice-class oil spill response vessel, ice-class anchor handling and support vessels, as well as two icebreakers "Kapitan Khlebnikov" and "Taymyr" equipped with spill response and ice management capabilities (See Table #10).

Table 10. Vessels engaged in the drilling operations at Universitetskaya-1 well in 2014.

Vessel	Ice class	Type	Additional equipment	Owner	Built	Flag
West Alpha rig	None	Jack-up rig	2 groups of blowout preventers; iceberg warning system	North Atlantic Alpha Ltd.	1986 - Tsu Shipyard, Japan	Panama
“Kapitan Khlebnikov”	Polar10	Icebreaker	Helipad, 2 hangars to accept 2 helicopters	FESCO - Far East Shipping Company	1981 – Wärtsila, Helsinki shipyard, Finland	Russia
“Taymyr”	Polar10	Icebreaker	Helipad, hangar for one KA-32 helicopter	FSUE Atomflot	1989 – Wärtsila, Marine Helsinki Shipyard, Finland; Baltic Shipyard	Russia
“Balder Viking”	DnV, ICE-10, +1A1	AHTS	-	Viking Supply Ships AS	2000 – Havyard Leirvik Norway	Sweden
“Brage Viking”	DnV ICE-1A Super, +1A1	AHTS	FiFi II, Oil.rec. NOFO2009, 120-200 evacuees	Viking Supply Ships AS	2012 - Astilleros Zamakona Pasaia – Pasajes, Spain	Norway
“Loke Viking”	DnV ICE-1A, +1A1	AHTS	FiFi II, Oil.rec. NOFO2009, 120-200 evacuees	Viking Supply Ships AS	2010- Astilleros Zamakona Pasaia – Pasajes, Spain	Norway
“Magne Viking”	DnV ICE-1A, +1A1	AHTS	FiFi II, Oil.rec. NOFO2009, 120-200 evacuees	Viking Supply Ships AS	2011 – Astilleros Zamakona Pasaia – Pasajes, Spain	Denmark
“SIEM Amethyst”	DnV ICE-C, +1A1	AHTS	Oil. Rec. NOFO2009, FiFi, De-ice	Siem Offshore Rederi AS	2011 - Kleven Verft AS	Norway
“SIEM Topaz”	DnV ICE-C, +1A1	AHTS	Oil. Rec. NOFO2009, FiFi II, De-ice, 300 evacuees	Siem Offshore Rederi AS	2010 – Kherson Shipyard - Kherson, Ukraine	Norway
“SIEM Pilot”	DnV ICE-C, +1A1	PSV	Oil. Rec., FiFi II	Siem Offshore Rederi AS	2010 - EIDSVIK SKIPSBYGGERI AS	Norway
“REM Server”	DnV ICE-C, +1A1	PSV	Oil. Rec.	Rem Supply AS	2011 - Vard Langsten–Tomrefjord, Norway	Norway
“REM Supporter”	DnV ICE-C, +1A1	PSV	Oil. Rec.	Rem Supply AS	2012 – Vard Langsten–Tomrefjord, Norway	Norway
“Island Crown”	DnV ICE-C, +1A1	OSV	Oil.Rec. Helipad, Medical personnel onboard	Island Offshore Group – Ulsteinvik, Norway	2013 – Vard Brevik – Brevik, Norway	Bahamas
“Botnica”	DnV ICE-10	Multi-purpose icebreaker	2* 5MW Azipods, helipad	TS Shipping Haren – Haren EMS, Germany	1998 – STX Finland Rauma – Rauma, Finland	Estonia
“RN Magellan”	Arc 4 (ICE-1A)	Chemical tanker	equipped with separate tanks to bunker vessels	RosNefteFlot, Russia	2007 – Ceksan Shipyard, Turkey	Russia
“Spasatel Kavdeykin”	ICE-1A*	Multi-purpose rescue vessel	DYNPOS-2, Oil.Rec., 2 skimmers	Rosmorrechflot -	2013 – Nevsky Shipyard, Russia	Russia

Many types of support vessels were used during the whole process of the drilling operation in the Kara Sea 2014: AHTS (anchoring and towing) vessels; passenger vessels; rig supply vessels; ice monitoring and defense vessels; oil spill recovery vessels; rescue boats, icebreakers and one oil tanker. Each of them had its own particular role in the operation according to Table #11.

As commented on the variety of the vessels by the interviewee of Russian oil company #2:*"More kinds of available marine units supporting offshore drilling operations provide reliability and flexibility when planning and executing drilling operations in harsh Arctic conditions"*.

Table 11. Vessels and their roles in the Kara Sea operation: P – primary function; S- secondary function; A – possible additional duties; P1 – "Botnica" could be used for transfer of the crew between the rig and "Island Crown".

Vessel	**Ice class in DNV-GL (or equiv.)**	**Anchor handling**	**Ice Defense & Reconnaissance**	**Ice Defense & Close Support**	**Rig supply**	**FiFi**	**Oil spill response**	**Crew change**	**Hospital**	**Storage of critical spare**	**Hotel**	**ROV**	**Cargo**	**Drilling**	**Fulling**
West Alpha rig	None	-	-	-	-	-	-	-	-	-	-	-	-	P	-
"Kapitan Khlebnikov"	Polar10 (LL3)	-	P	-	-	-	-	-	-	-	-	-	-	-	-
"Taymyr"	Polar10	-	P	-	-	-	-	-	-	-	-	-	-	-	-
"Balder Viking"	ICE-10, +1A1	P	P	A	S	A	-	A	-	-	A	-	A	-	-
"Brage Viking"	ICE-1A Super, +1A1	P	P	S	S	S	-	A	-	-	S	-	A	-	-
"Loke Viking"	ICE-1A, +1A1	P	P	S	S	S	-	A	-	-	S	-	A	-	-
"Magne Viking"	ICE-1A, +1A1	P	P	S	S	S	-	A	-	-	S	-	A	-	-
"SIEM Amethyst"	ICE-C, +1A1	S	S	P	P	P	S	A	-	S	S	-	A	-	-
"SIEM Topaz"	ICE-C, +1A1	S	S	P	P	P	A	A	-	S	S	-	A	-	-
"SIEM Pilot"	ICE-C, +1A1	-	-	S	-	A	-	A	S	-	-	-	P	-	-
"REM Server"	ICE-C, +1A1	-	-	A	-	-	-	A	S	-	-	-	P	-	-
"REM Supporter"	ICE-C, +1A1	-	-	A	-	-	-	A	S	-	-	-	P	-	-
"Island Crown"	ICE-C, +1A1	-	-	-	-	-	-	P	P	-	-	-	A	-	-
"Botnica"	ICE-10	-	A	P	-	-	-	P1	P	P	P	P	-	-	-
"RN Magellan"	Arc 4 (ICE-1A)	-	-	-	-	-	-	-	-	-	-	-	-	-	P
"Spasatel Kavdeykin"	ICE-1A*		A	S	-	-	P	-	-	-	A	-	-	-	-

The logistics operations required long and complex preparations. For instance, the icebreaker “Kapitan Khlebnikov” sailed towards the Kara Sea from the Vladivostok port via the Northern Sea Route. It is worth noting that it proceeded to the Pevek port independently, but then continued its journey to the drilling site under the escort of the atomic icebreaker Yamal as part of the first convoy from East to West[81]. Its journey took about 1 month from June 20 until July 20[82]. From July 20 to October 8, 2014, “Kapitan Khlebnikov” carried out duties in ice monitoring and ice protecting the “West Alpha” rig from ice. “Kapitan Khlebnikov” performed the reverse transition from the Kara Sea to the Vladivostol port independently without the atomic icebreaker escort. In total, the “Kapitan Khlebnikov” 's journey lasted 134 days, during this period it sailed 24,066 nautical miles.

Figure 58. ***“Kapitan Khlebnikov” icebreaker along the Northern Sea Route (Source: Fesco)***

The icebreaker “Taymyr” and “Balder Viking” set working their duties at the beginning of June long before the drilling operations themselves started. During June-July 2014, ice up to 2.5m thick remained in the Kara Sea and Kara Gate. Since the middle of June, both vessels conducted ground thrusting to determine the rate of the ice breakup and to confirm if the predetermined operational criteria were met. In addition, “Balder Viking” worked in the Kara Gate area to cut loose ice from coast, according to the interviewee of Norwegian shipping company #1. The Kara Gate area was emptied from ice within three days July 22-25, 2014.

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81 “Yamal” nuclear-powered icebreaker built in 1992 is able to overcome ice up to 2.5-2.9 m thick at an average speed of 3 knots. “Kapitan Khlebnikov” polar-class diesel icebreaker built in 1981 is able to overcome ice up to 1.5 m thick. “Taymyr” shallow-draft nuclear-powered icebreaker built in 1989 is able to overcome ice up to 1.7 m thick (the 1st author’s note).

82 For more information, see http://newsletter.towingline.com/NewsLetterPage/GetNewsLetter/47!36617/

Figure 59. The Kara Gate **area covered by ice and emptied from ice within July 22 and July 25, 2014 (Source: Viking Supply Ships).**

Then the pre-lay operations of anchors was done between July 27 and July 29.

On July 28, 2014, the West Alpha rig arrived at the staging area south of the Kara Gate and in accordance with the strategic configuration of ice defense and management, it was towed to the drilling site location in the Kara Sea (See Figure 61).

The well was actually drilled in open water during the ice-free season in August-September drilling period, but few and minor icebergs still expected and tracked through a tested ice management program. Thus, both icebreakers participated actively in ice management: one of them was on duty in the Kara Strait, and the other constantly examined the sea areas in a certain vicinity of the rig. In addition, the ice management program used proven technologies such as vessel radar, satellite and infrared imaging, visual observations and aircraft reconnaissance.

<u>Offshore facilities and sea supplies:</u>

The Universitetskaya-1 well was drilled using the West Alpha semi-submersible drilling rig, owned by Norway's North Atlantic Drilling[83]. The rig has a deadweight of 30,700 tons, 70 m long, 66 m wide, the derrick hangs 108.5 meters over the main deck. It is capable of drilling to a depth of up to 7 km. It made the way of over 1900 nautical miles to reach the drilling site in the Kara Sea.

The West Alpha rig underwent additional modernization to enable it to operate in the Arctic waters. It was equipped with an advanced iceberg warning system, which tracked potentially dangerous icebergs, giving enough time either for support vessels to tow them away, or for the rig itself to seal off the well and evacuate to safety.

[83] In order to fulfil its existing license obligations, Rosneft signed a long-term agreement in 2014 with the Norwegian company North Atlantic Drilling for the use of six offshore drilling rigs in its shelf projects, including its Arctic shelf projects, until 2022. To increase access to its drilling fleet, Rosneft also signed a framework agreement in 2014 with Seadrill Limited and North Atlantic Drilling Limited on the exchange of assets and investments (the 1st author's note).

Considering the extreme conditions, a special 3 weeks on - 6 weeks off rotating scheme was elaborated for the project workers.

Figure 60. The West Alfa drilling rig in the Kara Sea (Source: Livejournal.com)

The West Alpha drilling rig moved from "Westcon Yard" shipyard (Norway) towards the Kara Sea since the 20th of July 2014. It was escorted by a coast guard vessel. From the Pechora Sea into the Kara Sea through the Strait of the Kara Gate within July 28 and August 03, the rig was towed according to the strategic configuration of ice defense and management (See Figure 61). About 100 servicemen, including ice advisors and other special personnel, for quick release of anchor lines were taken onboard the West Alpha.

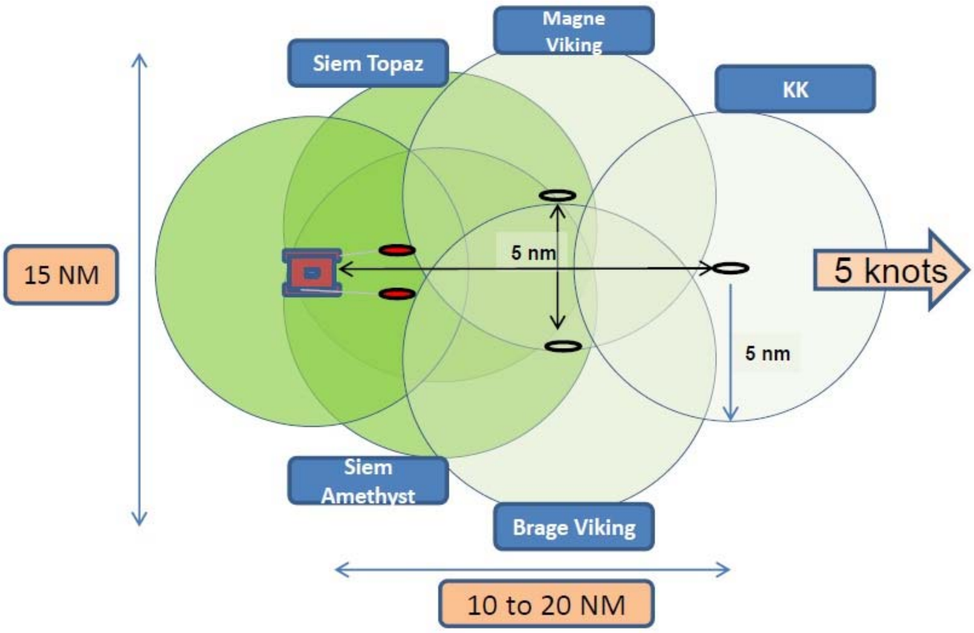

Figure 61. Ice defense base configuration during the towing of West Alpha to the Kara Sea (Source: Viking Supply Ships).

As told the interviewee of the Norwegian shipping company #1, four service vessels and "Kapitan Khlebnikov" icebreaker were involved in the rig towing and ice defense operation:

- Towing vessels: "Siem Topaz" and "Siem Amethyst" with (1) Norwegian ice advisor on each vessel.
- Ice defense vessels: "Magne Viking" and "Brage Viking" with (1) Norwegian ice advisor on each vessel.
- Ice defense reconnaissance vessel: "Kapitan Khlebnikov" icebreaker with Russian officers and crew.
- West Alpha: it took on board (1) lead ice advisor, (1) ice advisor, (3) radar/ice observers, (1) ice defense operations lead.

The crew onboard had limited ice arctic experience and the ice advisors had a special educational role, as told the interviewee of Norwegian shipping company #1.

Figure 61 illustrates the location of the vessels during the West Alpha towing through the Kara Gate.

Because the rig had no ice-strengthening, ice-free water along the towing route and around the drilling site was an absolute requirement. The convoy of four vessels and the icebreaker was not allowed to enter the narrow Kara Gate strait and then the Kara Sea before ice-free water in a radius of 40 nm from the drill site and no potential hazardous ice 10 nm on each side of the planned towing route could be documented. Towing speed in the Kara Sea was reduced to maximum 5knots from 9knots in the Barents Sea. In addition, a minimum weather window was required for leaving the staging area and entering the Kara Sea. It implies that many efforts had to be done in the field of ice reconnaissance and ice management.

As told the interviewee of the Norwegian shipping company #1, the following factors affected ice defense configuration:

- Natural conditions: wind, waves, rain, fog, icing;
- Radar, IR;
- Ice reports, overflight, satellite images, weather forecast;
- Tow speed;
- The Kara Gate's peculiarities: narrower formation, approximately 3nm between ice defense vessels.

On August 06, 2014, the rig was ready to drill.

The West Alfa was equipped with two groups of blowout preventers and an independent submarine locking device, which, in case of minor risks would seal the well. It was held at the drilling site by an anchoring positioning system, consisting of eight anchors. This guaranteed an elevate rig stability. Most of the rig was out of the reach of the waves, which did not impede the rig's operations.

Sharing his experience, the interviewee of Norwegian shipping company #1 told:

"The most important experience was how to operate in a very short operating window, trying to identify when the ice melts and when the ice freezes again. It was a crucial learning from the operation to identify when is the earliest point of time you can start and when is the latest point of time you have to leave the area. That was a crucial learning from the drilling campaign of 2014".

The West Alfa left Russia for Norway on October 8, 2014, following the completion of the Kara Sea campaign. The ice was not far behind, according to the interviewee of Norwegian shipping company #1.

As the interviewee of Norwegian shipping company #1 commented on the operations for towing of the rig and ice defensing in the Kara Sea:

"Good planning is the key! In order to handle the challenges, all parties involved have to be aware of the hazards and of what is required to mitigate the risks. A small thing can become a big problem in the remote Arctic. Well prepared scope includes defining the weak links, developing manuals of environmental issues description, using vessels and equipment suitable to the particular area, training the personnel".

In addition, the interviewee of Norwegian shipping company #1 stressed how much complicate the logistics preparation and the logistics in practice were during the whole drilling campaign of 2014 and added:

"The ice defense and reconnaissance implied a huge operation where we successfully provided a great service. However, the logistics was maybe where we did not actually provide the best service. It was a lot of failing and learning during those operations. The logistics could be more efficient what we plan to improve in the net campaign in 2019".

Aviation availability:

In addition to the vessels involved, an ice reconnaissance airplane were hired to fly on daily basis (or as often as needed) over the drill site and potential ice infested waters nearby. The airplane was equipped with Synthetic Aperture Radar (SAR) for ice detection under al weather conditions. The airplane was a fixed-wing Antonov-26 operated in a cooperation between Blom and AARI (Arctic and Antarctic Research Institute, St. Petersburg).

Helicopters could have been helpful for ice reconnaissance and personnel transfer, but they were excluded on a safety evaluation and Russian legal issues[84]. In spite of this, a drone was tested from the "Kapitan Khlebnikov" icebreaker for reconnaissance and ice drift measurements.

As told the interviewee of Norwegian shipping company #1:

"We were not allowed to use helicopter services during the drilling operations in 2014. I guess because of the vicinity of Russian military bases on Novaya Zemlya. There was a lot of submarine traffic in 2014 in the Kara Sea and some other legal issues. Even Head of Rosneft, Igor Sechin, used a helicopter just once from Rogachevo settlement, located on Novaya Zemlya. In his second arrival in September 2014, he spent two days sailing on a Russian research ship to the drilling rig to announce about the new unveiled oil deposit during a teleconference with President Putin. Otherwise, in case of the crew transportation and shift, it was not possible to use helicopters because the distance was too far."

Onshore operations and facilities:

The onshore facilities included the logistics supply base in Murmansk, the shore operation center in Moscow and infield operations command center on rig in the Kara Sea[85].

Figure 62. The locations of the offshore and onshore logistics base and operational center ***(Source: Viking Ice Consultancy)***

[84] It is worth noting that in fact helicopter services are widely used in the Kara Sea. For example, Gazprom used Ka-32 helicopter owned by "UTair – Helicopter services" in August, 2017 to explore a well at the Leningradskaya gas condensate field in the Kara Sea. "Utair-Helicopter services" has performed employee shift and cargo transport works for Rosneft after it won a tender for helicopter operations in July 2015. "UTair - Helicopter Services" has significant experience of performing offshore flights and providing air support for vessels in the Arctic oil and gas projects in Sakhalin, in the Kara Sea and Pechora Sea. Available on https://www.aex.ru/news/2017/8/1/173186/ and https://heli.utair.ru/en/o-kompanii/

[85] The infield operations command center on the rig was an offshore coordination center, but its activity closely related to the shore operation center located in Moscow. Thus, we describe it in sub-Section of Onshore operations and facilities (the 1st author's note).

The *logistics supply base* in Murmansk was established in 2014 by “Sakhalin-Shelf-Service”, LLC to support specifically the construction of exploration Universitetskaya-1 well in the Kara Sea. It was made total modernization of existing port facilities, including repairing of existing warehouse, building of a new warehouse, preparation of open storage areas, installation of mud and bulk plants. Besides, border checkpoint was organized in accordance with the norms and requirements of Russian Law. New cargo lifting equipment was purchased to meet the most contemporary safety requirements. The number of personnel was up to 100 people.

Facilities:	- Offices	200 м^2
	- Covered warehouses	2500 м^2.
	- Open storage areas	45000 м^2.
	- Berth	220 m^2
Main equipment:	- Mobile cranes, capacity	90 and 160 tons.
	-Forklifts, capacity	2,5-16 tons.
	-Port crane, capacity	32 tons
	-Telescopic loader, capacity	4 tons
	-Trucks, capacity	20 tons

The distance was over 1,600 km between the Murmansk supply base and the drilling site location in the Kara Sea. It required 3.5 days for the vessel sailing. Therefore, it took one week for the vessel to go forth and back to the Murmansk port to change the crew.

According to the interviewee of Norwegian shipping company #1:

“Actually, the distance between the supply base and the drilling location, as well as the complexity to predict changing ice conditions determined the number of vessels and their versatile types”.

The *Shore Operation Center (S-O-C)* was organized in Moscow to provide appropriate supply operation management and allocate all the resources efficiently.

As told by the interviewee of Norwegian shipping company #1:

“The shore operation center was like a brain storming area where ice advisors, ice analysts and meteorologists, including people from AARI, StormGeo, both oil companies, KSAT and others, worked together and prepared data about satellite imagery, aerial ice reconnaissance and weather forecasts. Then they distributed the data to the system “COPD – Common operational picture display in order to make everyone involved in the drilling campaign of 2014 be aware of the current situation: the weather and ice conditions, time data, the position of vessels and so on”.

Figure 63 illustrates the main principles of the shore operation center’s activities.

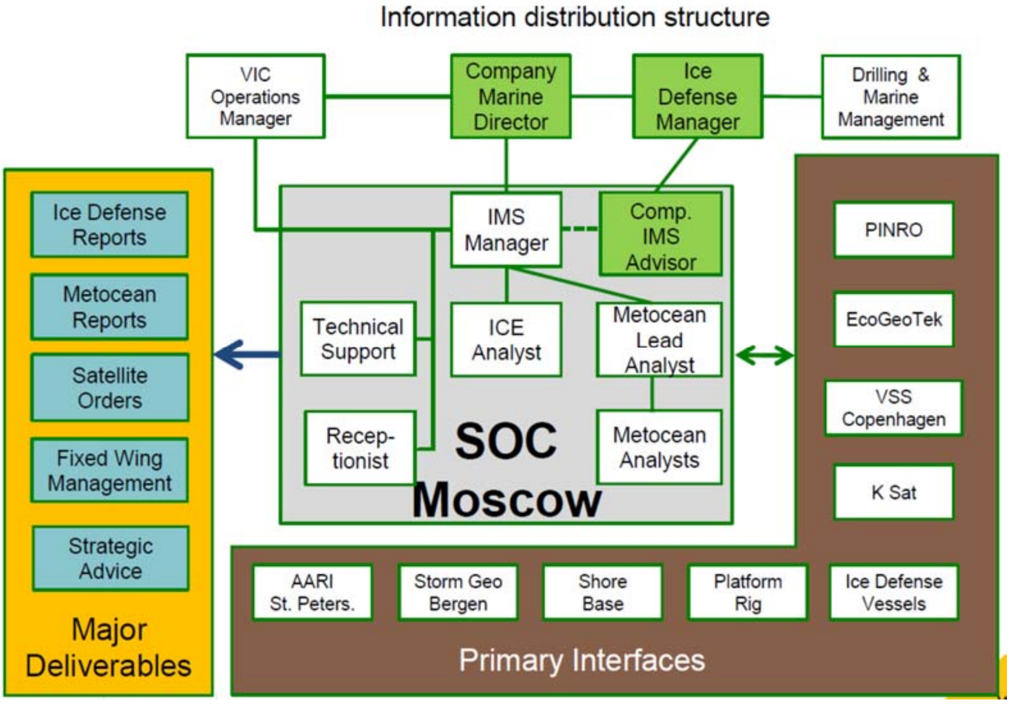

Figure 63. Shore operation center in Moscow for the drilling campaign of 2014 (Source: vikingsupplyships)

A special purpose information and communication system "COPD – Common operational picture display" was designed to share information, obtained in the shore operation center, between all project partners and make the operations safe and more effective (See Figure 64).

As told by the interviewee of Norwegian shipping company #1:

"The COPD – Common operational picture display made everyone involved in the drilling campaign of 2014 –people on the rig, from oil companies, crews on board, suppliers, vessel operators, staff from the shore and infield operation centers - be aware of the current situation: the weather and ice conditions, time data, the position of vessels and so on. Therefore, everyone could see the same operational picture in real time getting the same information and messages integrated in the single system".

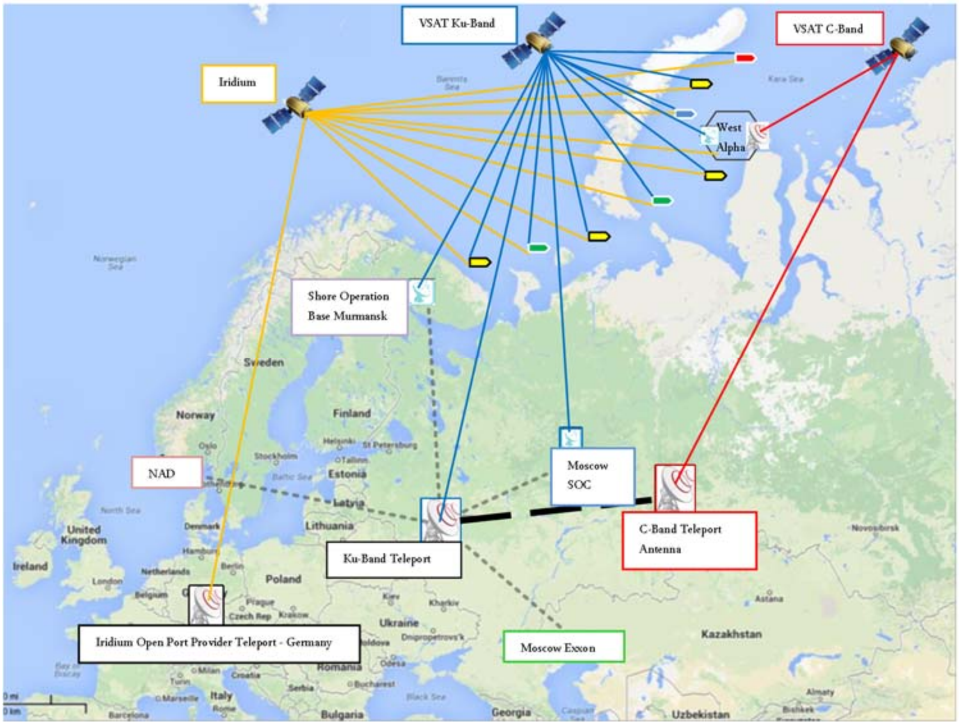

Figure 64. Communication system in the COPD – Common operation picture display (Source: Marine Technologies).

The *infield operations command center* was organized on the "West Alpha" rig in the Kara Sea to coordinate the operations in the field and ice defense activity in the different zones around the rig.

As told by the interviewee of Norwegian shipping company #1:

"The infield shore operation center included mainly ice advisors and meteorologists who monitored and determined if the ice was potentially hazardous for the vessels and rig or not. Then they reported and distributed data to the center in Moscow. The rig was equipped by special radars for ice observation".

3.2.2.3. Emergency preparedness logistics: SAR and oil spill response

In order to provide emergency preparedness for the operations in the Kara Sea, Rosneft established in 2012 a permanent Arctic base of rescue personnel and divers in Amderma, a village on the Kara Sea coast[86]. The initial task of the base is to support Rosneft's ongoing exploration activities in the Kara Sea. It includes a team of divers and a MI-8 helicopter[87]. Then the Amderma unit became a part of the federal rescue network. The divers came from a special operations team

[86] Amderma is located to the east of the Kara Gate on the coast of the Kara Sea. It has about 580 inhabitants now. In the late 1980s, about 5,000 people lived here. Amderma has an airport with several flights per week to Arkhangelsk (the 1st author's note).

[87] Available on https://www.marinelink.com/news/maritime/kara-sea

under the Arkhangelsk Regional Rescue Service, the only of its kind in Northwest Russia. All of the men have been part of a four-year special training program based on experiences from Norway, Sweden, Germany and the United States. In addition to the provision of emergency and rescue services, the base personnel makes regular ice monitoring missions to the areas of the seismic studies.

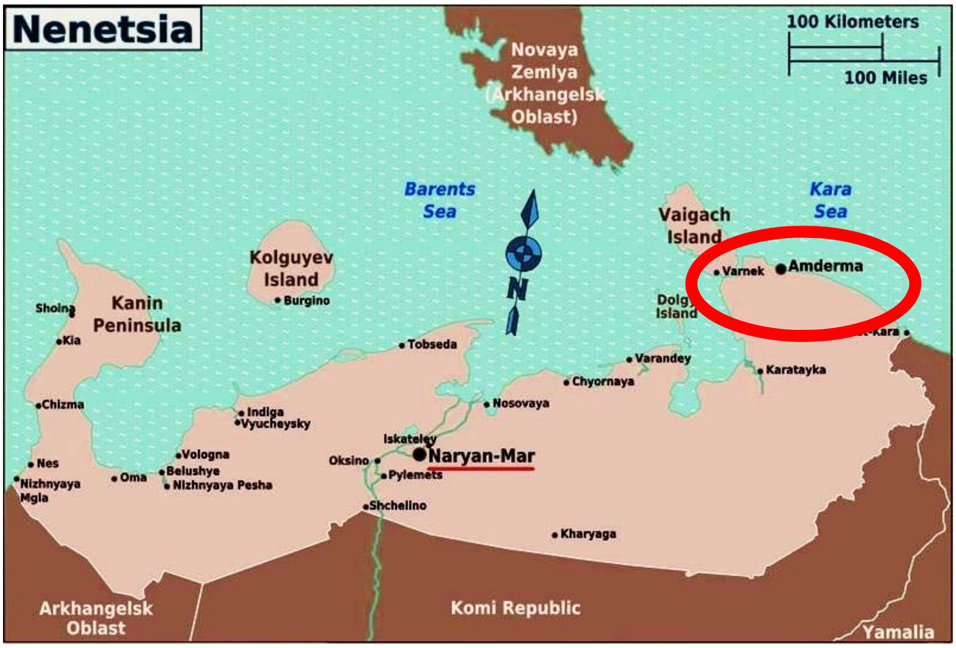

Figure 65. Location of Amderma village on the map
(Source: http://ultima0thule.blogspot.no/2016/04/naryan-mar-russian-arctic-town-in.html)

In case of medical emergency, no resources are available along the coasts of the Kara Sea and Novaya Zemlya. The closest hospital facilities are in Murmansk and Arkhangelsk that take approximately 3,5 days of sailing to be reached. In order to minimize the medical risks, just a few stand-by vessels had a dedicated hospital function like "Botnica" and "Island Crown" (See Table #11). In addition, paramedic trained officers were onboard most vessels.

The emergency preparedness and oil spill response was elaborated by professional emergency rescue team "ECOSPAS" and included the following activities:

- ice reconnaissance and monitoring of ice conditions in the area of the drilling operations;
- two vessels on duty near the West Alpha rig;
- oil spill prevention exercises for the personnel of Rosneft and ExxonMobil;
- providing support and protection to the West Alpha rig;
- the towing of the West Alpha rig as a safe support on its way to the Kara sea from the Pechora Sea and back;
- ensuring safety during the crew's shift from the vessel to the West Alpha rig and otherwise.

The oil spill prevention plan included vessels, aircrafts, data collection by satellites and drones.

As told the interviewee of Norwegian shipping company #1:

"It was the first experience when we tested the drone support. We used initially 6 drones, but then one crashed. It was useful because of low temperatures, poor JPS signals and magnetism".

The main resource in case of an oil spill was a dedicated response vessel "Spasatel Kavdeykin", which was located close to the West Alpha rig during the whole operation. In addition, just two of the AHTS vessels "Siem Amethyst" and "Siem Topaz" had onboard special equipment and trained operators for oil spill response (See Table #11). In case of a major spill, the closest base and depot for oil spill resources is located in Arkhangelsk, approximately 900nm away.

As the interviewee of Norwegian shipping company #1 shared his experience:

"Longer planning phase is needed to avoid expensive emergency scheduling. It's difficult also to plan satellite acquisition for the vessels sailing. All emergency systems should be tested in advance like SAR-imagery, specifically on board. We experienced how much this is important to have a back-up plan with additional access to, for example, satellite communication, not to make the vessels wait for the data of the real ice conditions. Without this info we could wait for extra 7-10 days for icebreaker assistance. For SAR and oil spill response operations, there is a challenge to predict exact vessel speed for tasking due to changing ice conditions, weather conditions that may result in operational delay".

There is no effective way of cleaning up an oil spill if it spreads under ice. Therefore, as an example Norway is not allowing oil drilling in icy waters. According to Greenpeace, Karmorneftegaz conducted the drilling operation in the Kara Sea where regulations do not require a relief rig that could be crucial stop a spill before it reaches the ice.

"The operation is the most extreme and remote drilling ever. If there is a spill, the effect might be catastrophic" – according to the Greenpeace's experts[88].

An ice advisor of Norwegian shipping company #1 shared his opinion on emergency preparedness during the drilling operation of 2014 in the ice conditions:

"I think we were not fully prepared to meet any challenges. We took just the best equipment and well-experienced trained people we had. However, in case of any possible oil spill there have not been a good efficient solution for today how to treat an oil spill in ice. You can burn it off, but

[88] Available on: http://www.greenpeace.org/sweden/Global/sweden/Arktis/Dokument/Exxon%20drilling%20plans%20in%20Russia_Brief.pdf

there is no vessel today that you can collect oil in ice, especially in ice constant drift when there is a lot of ice mixed with oil. When you start any operations in an area where the ice is and where the ice is constantly moving, you have to avoid anything going wrong by using vessels with high ice class and towing equipment".

This opinion can be confirmed by the practical long-term impacts of oil spills, which may persist for decades. For instance, lingering oil from the 1989 Exxon Valdez oil spill in Prince William Sound, Alaska has persisted far beyond initial forecasts. In 2005, it was discovered that oil only slightly weathered under beaches across the spill impact area. The lingering oil remains toxic and biologically available. The lingering effects of oil spills have also been documented in Cape Cod, Massachusetts, where recent studies found that oil remains in the sediment layer of some coastal marshes from a 1969 oil spill (WWF report, 2007).

3.2.3. Case 7. Dolginskoye field development project (the Pechora Sea)

3.2.3.1. Field location and natural conditions

General info and location:

The Dolginskoye oil field discovered in 1999 is located in the middle of the Pechora Sea, 120km south of the Novaya Zemlya archipelago and 110km north of the mainland. The license for oil exploration and production at this field was given to Gazprom in 2005.

The water depth in the field location varies from 20-25 m in South-East part to 40-45 m in North-West part. At the drilling site, the sea is approximately 35-55m deep. 2D seismic work has been carried out on more than 11,000 linear kilometers, and 3D seismic on 1,600 km^2. Four exploratory wells have already been drilled: three at North Dolginskoye and one at South Dolginskoye. Recoverable reserves are estimated to be in excess of 235 million tons of oil equivalent (1.7 billion barrels). It is the largest among discovered oil fields in the Pechora Sea. Production is expected to start in 2020, with peak levels of 4.8 million tons of oil per year to be achieved by 2026. The operator is Gazpromneft-Sakhalin, a subsidiary of Gazprom Neft.

Figure 66. The location of the Dolginskoye oil field in the Pechora Sea (Source: GazpromNeft-Sakhalin).

In August 2014, Gazpromneft-Sakhalin carried out the fourth drilling operations of an exploratory well (to a depth of 3,500 meters) in the northern part of the Dolginskoye field, located 90 km offshore. The completion of geophysical and hydrodynamic testing allowed clarifying the underlying structure of the field and the development of a program for its further investigation. This is the first time that such a major volume of work has been completed at a well during this region's short ice-free season. In November 2014, the well was abandoned, all equipment dismantled, and the empty wellhead hermetically sealed to ensure complete isolation from the external environment.

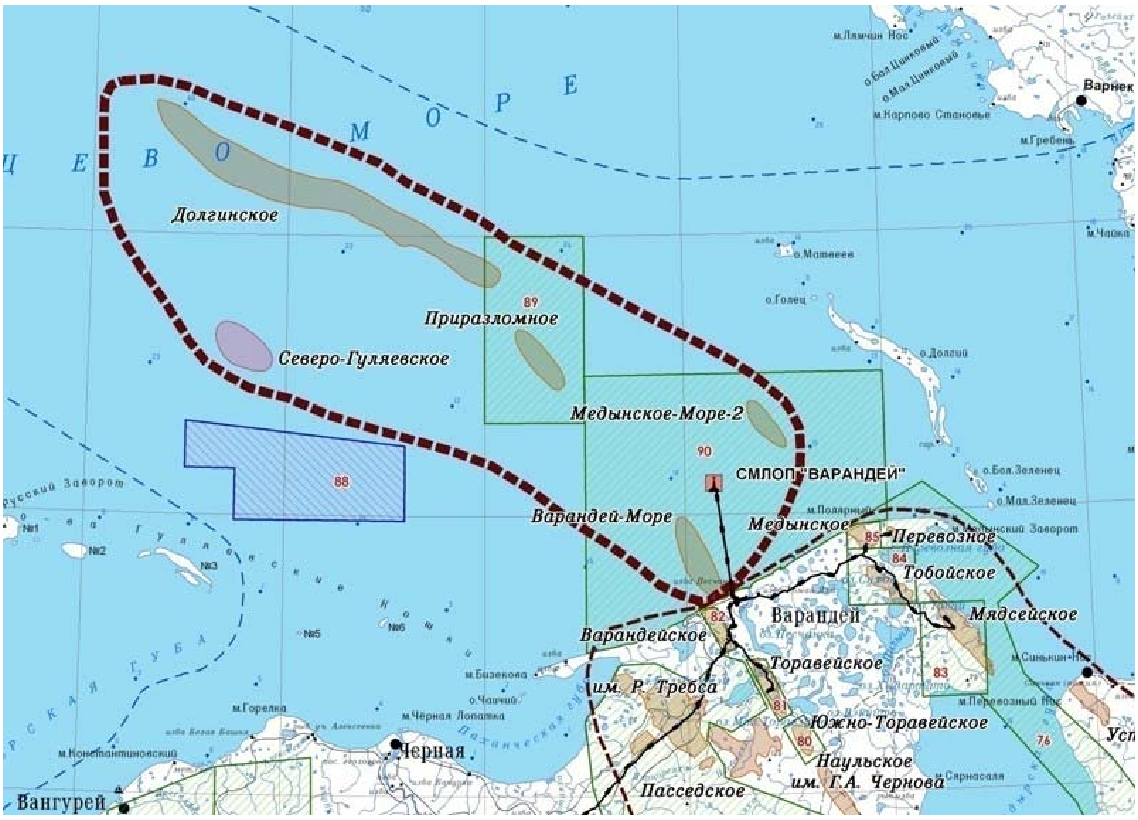

Figure 67 . The Dolginskoye field's location in the Pechora Sea (Source: sdelanounas.ru)

Natural conditions:

The length of the Pechora Sea is about 300 km from West to East and 180 km from North to South having the surface area of approximately 81 000 km^2 and the overall water volume of 4380 km^3. The Sea is shallow since its average water depth is around 6 m, but it gradually increases toward the North reaching the maximum depth of 210 m.

The typical environment of the Pechora Sea taken from the first source is given in Table #12.

Table 12. ***Typical environmental conditions of the Pechora Sea (Gudmestad et. al., 1999).***

Parameters:	
Maximum wind gust, m/s	41 m/s
Minimum air temperature, °C	-48
Sign. wave height, m	6,2 (at 45 m water depth)
Currents velocity, m/s	1
Freezing up (average)	Nov. (Oct.) – Eastern part of the Sea
Clearing (average)	June
Average open water, days	110
Multi-year ice, %	-
Maximum level ice thickness, m	1,3
Rafted ice thickness, m	2,6 (twice level ice thickness)
First-year ridge thickness, m	12-18
Multi-year ridge thickness, m	-

An air temperature is below 0 °C for 230 days per year. Air temperature at the Dolginskoye field varies from -46 °C in January to +26 °C in July-August. During the year the monthly average air temperature fluctuates from -17,4 °C in February to +6,5 °C in July, while the annual average value is about -5,1 °C.

In the summer season, a mean value of wind speed is about 6 m/s. During a storm, in the same season the speed can reach 20 m/s with duration of 6 hours in average and 36 hours at maximum. Even 30 m/s is possible with the maximum duration of 6 hours.

In the region of the Dolginskoye field average parameters of 10-100 year wave in the region are the following (Novikov, 2014):

- wave height – 3,2-4,7 m;
- wave length – 110-154 m;
- wave period – 8,6-10,5 s.

The sea is free of ice during about 110 days per year, but in the region of the field, the ice-free period can vary from 3 to 7 month (Novikov, 2014). Ice in the sea mainly has local origin, rarely accompanied with ice coming from the Kara Sea because of ice exchange between the seas. The thickness of level ice starts increasing in winter following the period of ice extension and reaches the maximum value, which is approximately 1.3 m in spring or beginning of summer. The extreme thickness is about 1.6 m. The thickness of rafted ice in the sea can be up to 2.5-3 m thick. In February, the sea surface coverage by hummocks can reach 60 to 80%, in April the hummocks can cover entire sea surface (Gudmestad, 1999

The oil and gas field development is a big challenge due to severe environment. Polar lows, strong winds, waves and currents accompanied with ice drift, ridges and icebergs can create huge loads on structures, which are aimed to develop the fields. Moreover, the sea depth variations lead to different structure design. For instance, an application of Gravity Based Structures in the Arctic is limited by approximately 100 meters depth. While floating or subsea units have much higher limits, it is impossible to install them in shallow water due to inefficient operability and higher costs comparing to gravity based structures.

3.2.3.2. Field logistics: offshore/onshore infrastructure and challenges

For the drilling operations at the Dolginskoye field in 2014, the GSP Saturn jack-up rig was used. The GSP Saturn was transported to the location by a special vessel "Hua Hai Long" in the OSV escort in the mid-June to ensure the utmost safety. Throughout the transportation from Vlissingen in the Netherlands to the platform's destination, a rescue vessel was on hand round the clock to supervise and respond immediately to any potential incidents. After the drilling operations were finished, the rig was towed to the port of Murmansk in November 2014.

The drilling operations were served by four vessels[89], presented in Table #13. Along with the four OSVs chartered for ancillary work, they were equipped with a DP-2 dynamic positioning system that allowed it to maintain a fixed position for loading in extreme weather conditions. The field's support fleet was equipped to all international naval safety standards.

The border checkpoint at Varandey airport was extended to allow flights to the Dolginskoye field. Until the drilling operations in 2014, the airport was only open for flights to the Prirazlomnoye platform[90].

[89] For more information, see http://pandia.ru/text/78/208/68042.php
[90] For more information, see https://sdelanounas.ru/blogs/51051

Figure 68. The GSP Saturn rig (Source: GazpromNeft-Sakhalin).

The platform was served by three AHTS vessels and one rescue vessel (See Table #13).

Table 13. ***Vessels engaged in drilling operations at Dolginskoye field in 2014.***

Vessel	Ice class	Characteristics	Additional equipment	Owner	Built	Flag
"Strilborg"	DNV +1A1, ICE-C	AHTS	Oil.rec. NOFO 2009, DYNPOS AUTR, FiFi I & II, 300 survivors	Simon Møkster Rederi AS	1998 – Builders Aukra Yard Norway	Norway
"Stril Challenger"	100A1, 1E	AHTS	Oil. Rec., NOFO2005, FiFi I, First-aid assistance, 280 survivors	Stril Offshore AS; c/o Simon Møkster Shipping AS	2009 - Havyard Leirvik AS	Norway
"Stril Commander"	100A1, 1E	AHTS	Oil. Rec., NOFO2005, FiFi I, First-aid assistance, 280 survivors	Stril Offshore AS; c/o Simon Møkster Shipping AS	2009 – Havyard Leirvik AS	Norway
"Spasatel Karev"	RMRS Arc5 (ICE-1A*)	Multipurpose rescue vessel - for oil spill response operations	DYNPOS-2, Oil.Rec., 2skimmers,	Marine Rescue Service of Rosmorrechflot – MRS, Murmansk, Russia	2010 – Nevsky Shipyard, St.Petersburg	Russian

According to the interviewee of Russian oil company #3, the company faced a number of logistics challenges when exploring the Dolginskoye field:

- *"In addition to the already familiar claims to severe climatic conditions, we experienced the rigidity of the project schedule how it is difficult to organize the full-fledged operations in a very short operating window until ice. We had only four months to deliver the drilling platform to the field site, install it, drill an exploration well, test it and then conserve it before the first ice comes. This considerably increases the cost of exploration".*

- *"Another logistics challenge we experienced was the need to use remote support infrastructure in Murmansk port located more than 750 km from the drilling well because the coastal service infrastructure in Varandey and Naryan-Mar, close to the work sites, was at the development stage. We found that supply market is quite undeveloped that required more our efforts to arrange the services of suppliers in time".*

Figure 69. The logistics scheme of drilling operations at Dolginskoye field, including the distances to the main infrastructure sites (Source: GazpromNeft-Sakhalin).

After completing the drilling operations at the Dolginskoye field, jack-up rig GSP Saturn was towed to Murmansk. Under its way to Murmansk, the rig was damaged in stormy weather by waves in the Pechora Sea. Reportedly GSP Saturn lost a lifeboat, the helicopter pad was damaged. It was decided to evacuate all the rig's personnel: 21 people went on board rescue vessel "Spasatel Karev", 25 persons went on board AHTS "Strilborg". The rig was towed by AHTS "Stril Challenger" and AHTS "Stril Commander", escorted by AHTS "Strilborg" and rescue vessel "Spasatel Karev"[91].

[91] For more information, see https://www.fleetmon.com/maritime-news/2014/5369/jack-rig-gsp-saturn-damaged-storm-pechora-sea-russ/

3.2.3.3. Emergency preparedness logistics: SAR and oil spill response

The rescue vessel “Spasatel Karev” remained on duty 24 hours a day while the rig was in operation at the field.

One of the measures to ensure that emergency preparedness is obligatory exercises for containment and response of oil and oil products spills during building of exploratory well N 3-SD of the Dolginskoye oil field. Oil spill response exercises were conducted July 17-18, 2014 by Russian Marine Emergency Rescue Service.

The oil spill response team was membered among others by multipurpose rescue vessel “Spasatel Karev”, AHTS “Stril Commander”, the “GSP Saturn” rig, MRCC Murmansk, Gazpromneft-Sakhalin LLC, one high-speed work boat, one boat-boner and about 80 crew members.

Figure 70. The oil spill response exercises during the drilling operations at the Dolginskoye field in 2014 (Source: Gosmorspassluzhba).

The exercises had the following purposes:

1. Cooperation organization training of SMPCSA Baltic Branch forces and facilities, operational and duty watch of Gazpromneft-Sakhalin LLC and SEFDR "GSP Saturn".

2. Check of emergency readiness level of forces and facilities during oil and oil products spills response.

3. Actions practicing for containment and response of oil and oil products spills[92].

[92] Available on http://www.nssz.ru/en/novosti/2014/the-vessel-spasatel-karev-took-part-in-trainings-of-the-pechora-sea-shelf.html

Figure 71. Participation of "Spasatel Karev" in oil spill response training in 2014 (Source: Marine Engineering Bureau).

3.2.4. Case 8. Sakhalin-1 oil and gas project.

3.2.4.1. Field location and natural conditions

General info and location:

The Sakhalin-1 project includes three offshore oil and gas fields: Chayvo, Odoptu, and Arkutun-Dagi, which underlie the sea bed of the Sea of Okhotsk off the northeastern coast of Sakhalin Island in the Russian Far East. The location of this project is not the Arctic region. This is the so-called sub-Arctic, which is characterized with hurricanes, prolonged blizzards, severe storms, typhoons and harsh ice conditions. This location in the Sea of Okhotsk experiences more dynamic ice conditions than many offshore areas north of the Arctic Circle. These factors greatly hinder offshore supply logistics and drilling operations, as well as pose serious threats for oil production facilities. We take this case for consideration in this report because of harsh environmental conditions of the location of the Sakhalin-1 Project that makes it interesting to illustrate the challenges and experience of oil and gas companies when developing these three oil and gas fields. This experience has a special meaning to be used for the development of the Arctic offshore field projects.

Sakhalin-1 is one of the largest oil and gas projects in Russia with direct foreign investment, implemented by an international consortium. The Consortium consists of the following representatives:

- Exxon Neftegas Limited, a subsidiary of American ExxonMobil (30%) – the project operator;
- Consortium SODECO (Japan) – 30%;
- Rosneft, JSC (Russia) acting via its affiliates: RN-Astra (Russia) – 8,5% and Sakhalinmorneftegaz-Shelf (Russia) – 11,5%;
- ONGC Videsh Ltd. (India) – 20%.

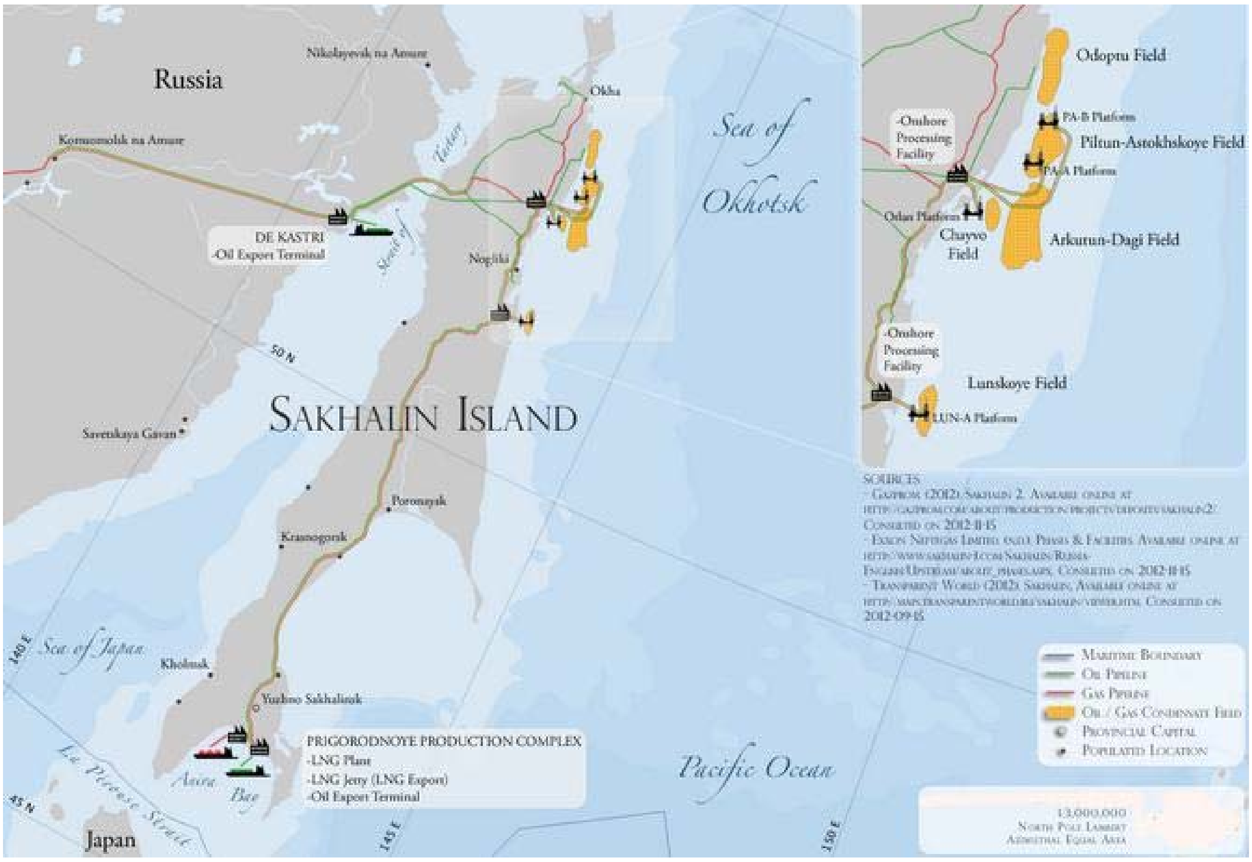

Figure 72. The Sakhalin-1 project location (Source: Exxon Neftegas)

Potential recoverable resources of the fields are estimated at 307 million tonnes (2.3 billion barrels) of oil and 485 billion cubic meters (17.1 trillion cubic feet) of natural gas.

The consortium works under a PSA (see Section 2.4.4). It means that the Sakhalin-1 project requires that the major amount of materials and resources be of Russian origin. Notably, more than 80% of the Sakhalin-1 project drilling rig operators are Russian nationals and project contract awards to Russian companies have reached approximately $3.8billion[93].

Each of three oil and gas fields has been developed in stages.

The Chayvo mainly gas field (discovered in 1979):

It was the first field to be exploited in the Sakhalin-1 project.

[93] For more information, see http://www.offshore-technology.com/features/feature1089/

The Chayvo field was the first field to be exploited in the Sakhalin-1 project. It was initially developed using both onshore “Yastreb” and offshore “Orlan” drilling facilities. While the Orlan platform has been in continuous operation there, the Yastreb drilling rig was dismantled and moved to the Odoptu field in July 2008. After successfully completing the Odoptu First Stage Production drilling program in February 2011, the Yastreb is currently being relocated back to Chayvo to resume development of the field.

The Odoptu oil and gas field (discovered in 1977):

The Odoptu field is located 70 km north of Chayvo and is very much different, which affected the drilling process. Even the Yastreb drilling rig temporarily relocated to a new site had to be modernized. The first well drilling at Odoptu started in 2009. Drilling operations at this location were completed over the next two years with 9 wells drilled and several world records set. Upon completion of drilling operations at Odoptu, the Yastreb drilling rig was decommissioned and returned back to Chayvo. In addition, a new drilling rig similar to Yastreb has been shipped to site and is expected to commence operations there in the nearest future.

The Arkutun-Dagi oil and gas field (discovered in 1989):

Arkutun-Dagi is the third and final field developed as part of the larger Sakhalin-1 project. Discovered in 1989, the Arkutun-Dagi oil and gas field is located 25km offshore Sakhalin Island in the sea of Okhotsk, approximately 25km east of the Chayvo field and 18km north-east of the Orlan platform. The field is located at water depths ranging from 15m to 40m, and developed in phases starting from the northern section. The Arkutun-Dagi field is being developed using an ice-resistant fixed platform named “Berkut”.

Production from the Arkutun-Dagi field’s first well started in January 2015. It is expected to increase to a peak of 85,000 barrels of oil a day by 2019. The field will increase the annual production capacity of Sakhalin-1 by 32.5 million barrels (4.5 million tonnes) of oil. The total annual production from Sakhalin-1 project is estimated to exceed ten million tonnes by 2018.

Natural conditions:

The Sea of Okhotsk is subject to dangerous storm winds, severe waves, icing of vessels, intense snowfalls and poor visibility. The average annual extreme low ranges between -32°C and -35°C. Ice sheets up to 1.5m thick move at speeds of 1-2 knots.

Offshore structures can be exposed to icing from October through to December, for around 187 days. During the ice-free period, wave heights range between 1-3m, but can reach as high as

19m during 100-year storm conditions. Strong northeast and southeast winds cause a great amount of sea agitation in autumn and winter.

3.2.4.2. Field logistics: offshore/onshore infrastructure

<u>Offshore facilities and sea supplies:</u>

"Orlan" offshore platform:

The Orlan platform is a gravity base structure (GBS) set in around 14 m of water in the south-west sector of the Chayvo field, installed in July 2005. It assists the Yastreb onshore drilling rig. This platform is able to withdraw ice, sea waves and large subsoil oscillations. It was designed for year-round exploration drilling in arctic waters at depths up to 15m.

The "Orlan" characteristics:

- platform weight = ab. 70,000 tonnes;
- length = 96 m
- width = 89.9 m
- total base height = 30 m
- seismicity = up to 8 points;
- wave height = up to 13 m;
- ice and hummocks in height = up to 6 m;
- number of wells = 20
- maximum oil production = 23 tons per day

On the platform, about 100 people work for a month. The shift is 28 days. Work watch is 12/12 hours.

In order to maximize the drilling space on the "Orlan" platform, minimal integral processing facilities are included offshore. The well stream is exported to the onshore processing facility where it co-mingles with the Chayvo stream. The stabilized crude oil is shipped to the newly-constructed DeKastri terminal in the Khabarovsk Region terminal for export, while the natural gas is supplied to the Russian Far East or injected back into Chayvo for reservoir support. This was based on a 140-mile (225km) pipeline to the Chayvo onshore processing facility.

Figure 73. The "Orlan" platform in the Sea of Okhotsk, "Vitus Bering" supply vessel and "Kigoriak" anchor-handling vessel (Source: https://russos.livejournal.com/1201698.html)

"Berkut" offshore platform:

"Berkut" is an ice-resistant fixed platform at the Arkutun-Dagi field, installed in 2012. that is the largest oil and gas production platform in Russia. The platform is placed on top of a gravity-based structure (GBS) fixed to the seabed at a depth of 35m. A total of 45 wells, including 28 oil producing wells, 16 water injection wells and a cutting re-injection well, was drilled at Arkutun-Dagi.

Production from the Berkut platform commenced in January 2015. Oil produced from the field is transferred to the existing Chayvo onshore processing facility (OPF) via an approximately 25km-long well-stream flowline and further to the De-Kastri export terminal, while natural gas is sold domestically.

The "Berkut" platform is designed to withstand extreme temperatures of up to -44°C, waves up to 18m-high and pressure of 2m-thick ice. The platform is 105m long, 60m wide and 144m high. Its topside is equipped with a drilling rig, processing facilities, living quarters, a helipad and ancillary facilities. The topside weighs 42,000t, while the total weight of the platform exceeds 200,000t. The drilling rig has a top drive of 142kN/m and a lifting capacity of 1,150t.

More than 4,000 people were involved during construction of the "Berkut" platform. Because of this, in the beginning of 2014, Sea Trucks Group's "Jascon 34", a pipelay construction vessel (built in 2010, flag: Gibraltar; accommodation complement 335 prs.), provided additional accommodation support for personnel of "Berkut" platform and lifting services. The capacity of the "Jascon 34" vessel was increased with modular accommodation units to accommodate up to 595 people on board[94].

Figure 74. Jascon 34 vessel near "Berkut" platform (Source: offshoreenergytoday.com)

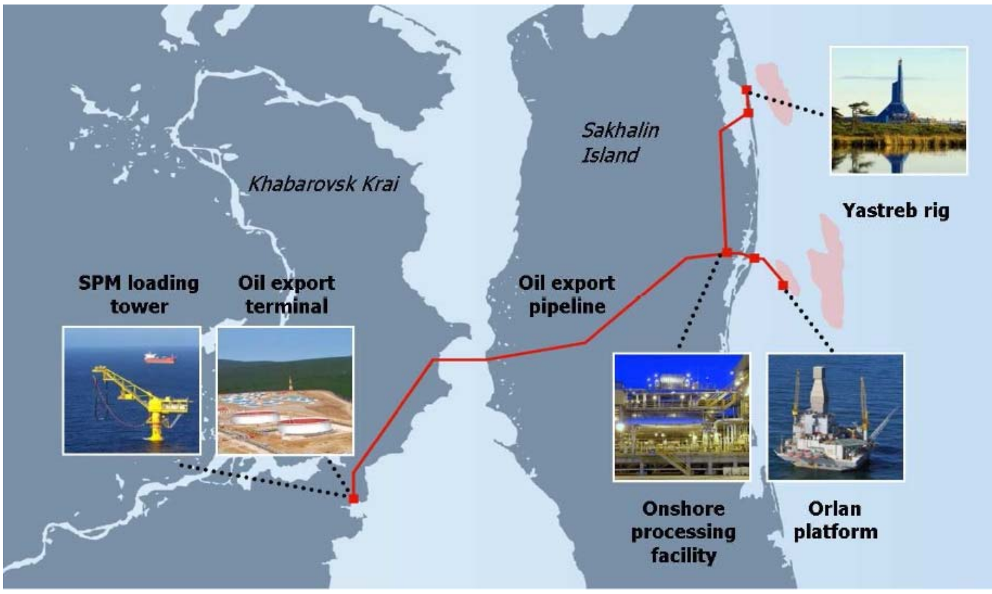

Figure 75. Sakhalin-1 project facilities (Source: Sakhalin-1.ru)

Maritime vessel availability:

Three of SCF Group's multi-purpose ice-breaking supply vessels – "Vitus Bering", "Aleksey Chirikov" and "SCF Sakhalin" service the drilling platforms "Orlan" (Chayvo field) and "Berkut" (Arkutun-Dagi field). All of these vessels work under long-term contracts with the project operator. These icebreaking platform supply and stand-by vessels assist to meet the demanding conditions, including the shallow depth of water around the platform. They are

[94] For more information, see https://www.marinelink.com/news/contract-brings-trucks361051

designed to operate in temperatures down to -40⁰ C and to cope with solid ice 1.5m thick and ice ridges of up to 20m deep. The vessels are fitted with two Azipod propulsion units and uses the double-acting concept developed by Aker arctic technology (See Table #14).

"Kigoriak" icebreaker is constantly near the "Orlan" platform and responsible for emergency preparedness.

Figure 76. "Kigoriak" icebreaker (Source: https://russos.livejournal.com/1201698.html)

In addition, the icebreakers – "Admiral Makarov", "Krasin" and "Kapitan Khlebnikov" carry out the icebreaker escort of the OSVs involved the during the winter navigation.

In 2005, "Vengery" (former "Crowley Alliance") vessel, owned and operated by Crowley Sakhalin LLC, served the "Orlan" platform. The vessel – AHTS, Ice Class 1A Super. It provided an ice strengthened anchor handling tug, ocean towing and general supply duties for the project. In order to provide this service on a long-term basis, the vessel was flagged under the Russian Federation and crewed by Russian Nationals. "Crowley Alliance" vessel had the hull strength and power to break first year ice up to 1m (39in) thick, and during the most severe part of the Sakhalin winters followed an icebreaker to the Orlan location.

Table 14. ***Vessels serve “Berkut” and “Orlan” platforms in the Sakhalin-1 project.***

Vessel	Ice class	Characteristics	Additional equipment	Owner	Built	Flag
“Kigoriak”	Ice class 3	Anchor handling vessel; Gross tonnage 3898 tons	Oil.rec., FiFi	FEMCO Management – Yuzhno Sakhalinsk	1979 – Saint John Shipbuilding (Canada)	Russia
“SCF Sakhalin”	ICE-10 Icebreaker	Platform supply and stand-by vessel	Diesel-electric 2 × ABB Azipod VI1600, KaMeWa Ulstein TT2200 bow thrusters, winterized, 150 evacuees, oil spill response gear, an arctic oil skimmer, 200m of oil boom, a reception tank for oily water	SCF Sakhalin Vessels Limited (Sovcomflot)	2005 - Aker Finnyards, Helsinki, Finland	Russia
“Vitus Bering”	Icebreaker6	Platform supply and stand-by vessel	Two ABB Azipod VI1600 units; two bow thrusters, winterized, 195 evacuees	Owner: Dafne Line Shipping; Operator: Sovcomflot	2012 – Arctech Helsinki Shipyard, Helsinki, Finland	Russia
“Aleksey Chirikov”	Icebreaker6	Platform supply and stand-by vessel	Two ABB Azipod VI1600 units; two bow thrusters, winterized, 195 evacuees	Sovcomflot	2012 – Arctech Helsinki Shipyard, Helsinki, Finland	Russia
“Tor Viking”	Icebreaker6, DNV ICE-10	AHTS	Winterized	Viking Supply Ships	2000 - Havyard Leirvik AS	Sweden/ Russia
“Admiral Makarov”	ICE-1B (LL2)	Icebreaker	Helipad and hangar	FESCO Far East shipping company	1975 - Helsinki New Shipyard, Helsinki, Finland	Russia
“Krasin”	ICE-1B, LL2	Icebreaker	Helipad and hangar	FESCO Far East shipping company	1976 – Wärtsilä Helsinki Shipyard, Helsinki, Finland	Russia
“Kapitan Khlebnikov”	Polar10	Icebreaker	Helipad, hangar for one KA-32 helicopter	FESCO Far East shipping company	1981 – Wärtsilä Helsinki shipyard, Finland	Russia
“Vengery” – served “Orlan” platform only in 2005-2006	1A Super	AHTS	Decommissioned currently	FEMCO Management	1983 - Hyundai Heavy Industries, Ulsan, Korea	Russia

Oil is transported from the De-Kastri oil loading terminal, which includes two 100,000 cubic meters (650,000 barrel) capacity storage tanks to hold the Sakhalin-1 crude oil prior to tanker transfer and shipment. Then the crude is transported via a sub-sea loading line to the single point mooring facility, which is located 5.7 kilometers east of the Klykov Peninsula in Chikhacheva Bay. Tanker loading operations began at De-Kastri in September 2006. By September 2016, 781 tankers were loaded. The terminal has safely transported more than 60 million tons of stabilized crude oil without incident.

Figure 77. ***De-Kastri Terminal and Aframax shuttle tanker (Source: Exxonmobil.com)***

The loading speed is 7,700 tons/hour, the full tanker is loaded for 13 hours.

The De-Kastri is located 5.7 km south-east of the onshore oil terminal. The water depth is 21 m, the height is 82.5 m above the seabed, the weight is 3,773 tons. The rotating boom is 360 degrees, the departure is 49m.

The special icebreaking tugboat “Pevek” is operated at the loading terminal water area during the tankers loading process to ensure the safe and effective loading operations.

Currently five of SCF’s doubled-hulled Aframax-class shuttle tankers with a high ice class are engaged in transporting oil from the terminal: “Yuri Senkevich”, “Viktor Titov”, “Victor Konetsky”, “Captain Kostichev” and “Pavel Chernysh”. Carrying year-round up to 100,000 tons (720,000 barrels) of crude are used for export of crude oil from the De-Kastri Terminal to world markets (See Table #15).

Table 15. ***Vessels serve De-Kastri oil terminal in the Sakhalin-1 project.***

Vessel	**Ice class**	**Characteristics**	**Additional equipment**	**Owner**	**Built**	**Flag**
“Polar Pevek”	ICE-10, DnV 1A1	Icebreaker Tug	FiFi 1	Rieber Shipping ASA / Primorsk	2006 – Aker Langsten	Russia
“Admiral Makarov”	ICE-1B (LL2)	Icebreaker	Helipad and hangar	FESCO Far East shipping company	1975 - Helsinki New Shipyard, Helsinki, Finland	Russia
“Krasin”	ICE-1B, LL2	Icebreaker	Helipad and hangar	FESCO Far East shipping company	1976 – Wärtsilä Helsinki Shipyard, Helsinki, Finland	Russia
“Kapitan Khlebnikov”	Polar10	Icebreaker	Helipad, hangar for one KA-32 helicopter	FESCO Far East shipping company	1981 – Wärtsilä Helsinki shipyard, Finland	Russia
“Yuri Senkevich”	+1A1, ICE-1C	Aframax shuttle tanker (double-hulled)		Sovcomflot	2005 - Hyundai Heavy Industries, Korea	Cyprus
“Viktor Titov”	+1A1, ICE-1C	Aframax shuttle tanker (double-hulled)		Sovcomflot	2005 - Hyundai Heavy Industries, Korea	Cyprus
“Viktor Konetsky”	+1A1, ICE-1C	Aframax shuttle tanker (double-hulled)		Sovcomflot	2005 - Hyundai Heavy Industries, Korea	Cyprus
“Captain Kostichev”	+1A1, ICE-1C	Aframax shuttle tanker (double-hulled)		Sovcomflot	2005 - Hyundai Heavy Industries, Korea	Cyprus
“Pavel Chernysh”	+1A1, ICE-1C	Aframax shuttle tanker (double-hulled)		Sovcomflot	2005 - Hyundai Heavy Industries, Korea	Cyprus

Icebreakers provide support of tankers in winter period that allows to carry loading operations on a year-round schedule. The icebreakers “Admiral Makarov”, “Krasin” and “Kapitan Khlebnikov” are involved in escort operations (See Figure 78).

During the ice season, Arctic and Antarctic Research Institute (AARI) supports the loading operations by providing the live and forecast data of ice conditions and meteorological data and route planning by tankers in the Tatar Strait, according to the interviewee of Russian oil company #2.

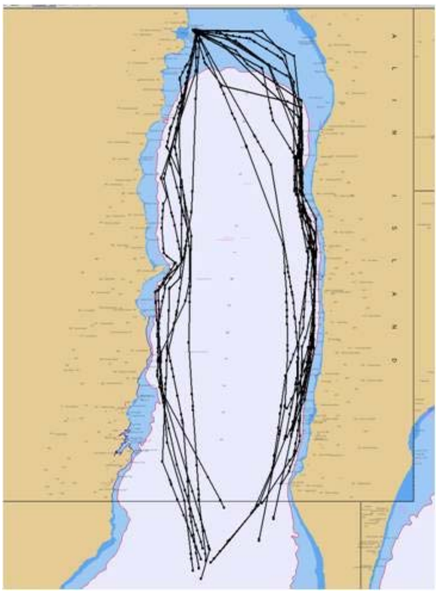

Figure 78. Icebreakers duties and oil tankers routing map (Source: Rosneft)

Most part of ice concentration is located to the south of De-Kasti. The icebreaker break the ice in area around the oil loading terminal, but this is done by a different icebreaker than those which support tankers. Ice around the oil loading point is crashed by the icebreaker “Polar Pevek”. When loading operations are quite often, it happens that the area can stay ice-free and then there is no need for extra use of icebreakers, as told by the interviewee of Russian oil company #2.

Figure 79. The icebreaker escort of an oil tanker in the Tatar Strait from the De-Kastri oil terminal (Source: Rosneft).

The formation of ice coverage in the Tatar Strait usually begins in November-December. Oil tankers escort operations is carried out from mid-December to end of March. Depending on the ice conditions, one or two icebreakers involves in escort operation (See Figure 80).

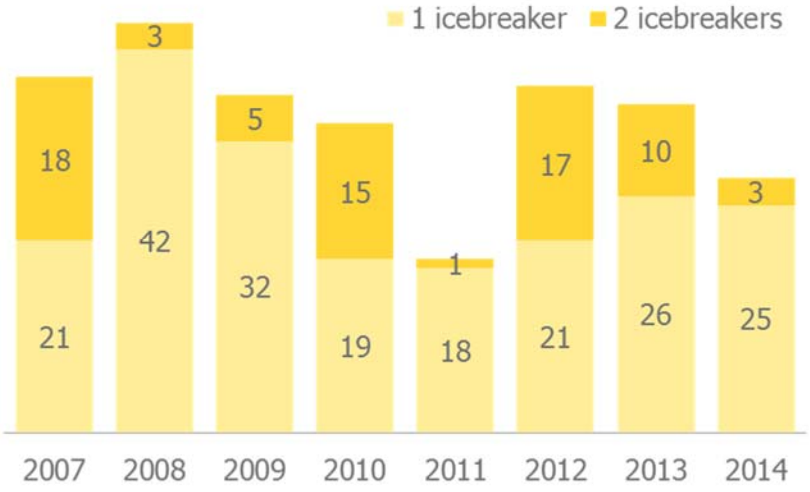

Figure 80. Icebreakers support operations in the Tatar Strait for the oil tankers from 2007 to 2014 (Source: Rosneft)

Onshore facilities:

Onshore processing facilities include several units:

- "Yastreb" land drilling rig is one of the most powerful land rigs in the industry. It is designed to drill extended reach wells to offshore targets from land-based locations.
- The Chayvo Onshore Processing Facility receives oil and gas produced from the Sakhalin-1 fields and then stabilizes oil for shipment to the international market and gas for supply to the Russian domestic market or reinjection to the field to maintain reservoir pressure.
- Sakhalin-1's oil transportation system was commissioned in August 2006. Construction was completed on a 226 kilometer (140 mile) pipeline to transport crude from the onshore processing facility across Sakhalin Island and the Tatar Strait to the De-Kastri Terminal in Russia's Khabarovsk Krai.

There are several supply bases to provide supply deliveries under "Sakhalin-1" project, presented on Figure 81:

Figure 81. The location of the supply shore bases on Sakhalin (Source: Sakhalin-Shelf-Service, LLC).

- Korsakov shore base in Korsakov Marine Trade Port (founded in 1997). During 20 years of its operation, Korsakov supply base has fully supported all activities of exploration drilling, process all cargo and equipment, required for construction of Chayvo and Odoptu platforms as well as onshore drilling facility "Yastreb". In addition, the base has processed cargo for "Orlan" drilling platform[95].

Facilities:	- Offices	102 м^2
	- Warehouses	2000 м^2.
	- Open storage areas	10400 м^2.
Main equipment:	- Mobile cranes, capacity	50-160 tons.
	-Forklifts, capacity	5-10 tons.

Figure 82. The Korsakov shore base on Sakhalin (Source: Sakhalin-Shelf-Service, LLC).

[95] At the moment, the Korsakov shore base provides services under "Sakhalin-3" project (the operators are LLC "Gazpromgeologorazvedka" & LLC "Gazprom Flot"). For more information, http://www.sssc.ru/engpage_27.html

- Sakhalin Western Seaport (founded in 2002) near Kholmsk settlement is the most modern port on Sakhalin and the only port on the Far East, specialized on supporting oil and gas projects. Since 2005, it has been functioning as unified onshore supply base for "Sakhalin-1" and "Sakhalin-2" projects[96].

Facilities:	- Offices	2000 м^2
	- Warehouses	30000 м^2.
	- Open storage areas	70000 м^2.
	- Berths	1090 m
	- Railway spurs	2,5 km
Main equipment:	- Port cranes, capacity	20 tons.
	- Forklifts, capacity	1,5-23 tons.
	- Mobile cranes, capacity	50-150 tons
	- Port cranes, capacity	32 tons
	- Port cranes, capacity	60 tons
	- Gantry cranes, capacity	20-32 tons
	- Trucks, capacity	20 tons

- Kholmsk shore base located in Kholmsk Marine Trade Port is used as a supplementary facility (mostly for the needs of Sakhalin-2 project).
- Yuzhno-Sakhalinsk operations base (founded in 1998) maintains equipment and provides cargo transportation, as well as there are hazardous waste (I-IV class) treatment facilities.

Facilities:	- Offices	450 м^2
	- Warehouses	4306 м^2.
	- Open storage areas	20000 м^2.
Main equipment:	- Mobile cranes, capacity	50-90 tons.
	- Forklifts, capacity	3-5 tons.
	- Low boy truck with trailer	75 tons
	- Trucks, capacity	18-42 tons

- Nogliki Supply Base (founded in 2006) provides continuous supply of diesel fuel by trucks for OPF generators, which produce electric power for LUN-A drill platform. There is satellite communication system and 24-hours monitoring system to monitor vehicles' movement. There was developed oil spill response plan for quick oil spill response[97].

Facilities:	- Office	70 м^2
	- Warehouse	4660 м^2.
	- Open storage area	10000 м^2.

[96] It is worth adding that since 2009 Sakhalin Western port provides services also for "Sakhalin-3" project (LLC "Gazflot" – in 2014 renamed into LLC "Gazpromflot"), in 2013 – for LLC "Gazprom Geologorazvedka", providing services for new drilling platforms. Today, this port provides services for all Sakhalin shelf projects. Besides, it provides services for line vessels (LLC "FESCO Integrated Transport") and tramp vessels as well.
For more information, see http://www.sssc.ru/engpage_29.htm

[97] For more information, see http://www.sssc.ru/engpage_32.htm

Main equipment:

- Fuel truck KAMAZ
- NEFAZ" bus for crew change
- Escort vehicles - Land Cruiser
- KAMAZ with oil spill response equipment

- Wakkanai shore base (founded in 2000) in Wakkanai Japanese port provides winter parking for rig installations and specialized support fleet.

Figure 83. The Wakkanai shore base (Source: Sakhalin-Shelf-Service, LLC).

3.2.4.3. Emergency preparedness logistics: SAR and oil spill response

Emergency risk analysis conducted in the course of the Sakhalin 1 implementation showed that incidents involving oil and product spills could cause the greatest damage to the environment. The Sakhalin 1 Oil Spill Response and Prevention Plan was approved by the Ministry of Civil Defense and Emergencies and other regional and federal authorities.

The plan covers all oil product spills that may occur at ENL oil production and export facilities for the Sakhalin 1 Project located on the Sakhalin Island shelf, on Sakhalin Island, and in the Tatar Strait, as well as in some Khabarovsk Krai mainland areas, including:

♦ the Sea of Okhotsk;

♦ coastal zones, including Chayvo Bay and Piltun Bay on the northeast coast of Sakhalin Island;

♦ land areas along the routes of main and field pipelines in northern Sakhalin Island;

♦ the Tatar Strait and Nevelskoy Strait, including the west coast of Sakhalin Island and the coastal areas of Khabarovsk Krai.

In 2016, 30 minor oil and petroleum product spills as a result of construction and production activities were recorded at ENL facilities, of which 29 occurred at production sites in Sakhalin Oblast, and 1 occurred at the production site in Khabarovsk Krai (not from marine vessels). The total volume of spilled oil and petroleum products was 787.54 liters. All these spills occurred within boundaries of the company's industrial sites and were immediately and fully cleaned up.

The main reason for such spills/leaks of petroleum products such as hydraulic fluids, lubricating oils, diesel fuel is the failure of mechanisms of heavy machinery and motor vehicles used in production activities at the Sakhalin-1 Project sites. Due to the start of construction at the Odoptu Well Site 2 (South) and repair of the piping network at the production site of the Chayvo Onshore Processing Facility, the volume of oil and petroleum products spills/leaks increased slightly in 2016 compared to 2015. The consequences of the leakage were eliminated immediately.

The Orlan and Berkut fixed offshore platforms for the Sakhalin-1 Project are equipped with an internal drain system operating in a closed loop. In the event of leakage of oil or oil products on any of the platform decks, all liquids are confined in the drain system, which keeps them out of the environment.

In each case of oil product leaks, a written report was prepared, and an investigation and analysis of the causes was conducted[98].

Figure 84. Safe boats on the «Orlan» platform (available on https://russos.livejournal.com/1201698.html)

It is worth adding that spreading and movement of the oil spill on the sea surface was simulated in the SIMAP model for the worst-case scenario for the volumes calculated in accordance with the requirements of the RF Government Resolution No. 1189 of November 14,

[98] For more information, see http://cdn.sakhalin-1.com/~/media/sakhalin/files/environmental-policies/2016-enl-report-on-environmental-protection-activities-2016.pdf

2014 "On Management of Oil and Petroleum Product Spill Prevention and Response on the Continental Shelf of the Russian Federation and in Inland Sea Waters, Territorial Waters, and the Contiguous Zone of the Russian Federation"[99].

3.2.5. Case 9. Sakhalin-2 oil and gas project.

3.2.5.1. Field location and natural conditions

General info and location:

The Sakhalin-2 project is an oil and gas development in Sakhalin Island, Russia. It includes development of the Piltun-Astokhskoye oil field and the Lunskoye natural gas field offshore Sakhalin Island in the Okhotsk Sea, and associated infrastructure onshore.

The project is managed and operated by Sakhalin Energy Investment Company Ltd. (Sakhalin Energy). Shareholders of Sakhalin Energy are:

- Gazprom Sakhalin Holdings B.V. (subsidiary of Gazprom) - 50% plus 1 share;
- Shell Sakhalin Holdings B.V. (subsidiary of Royal Dutch Shell) - 27.5% minus 1 share;
- Mitsui Sakhalin Holdings B.V. (subsidiary of Mitsui)- 12.5%;
- Diamond Gas Sakhalin (subsidiary of Mitsubishi) - 10%.

[99] For more information, see http://cdn.sakhalin-1.com/~/media/sakhalin/files/environmental-policies/2015-enl-oil-spill-response-plan-summary-eng.pdf

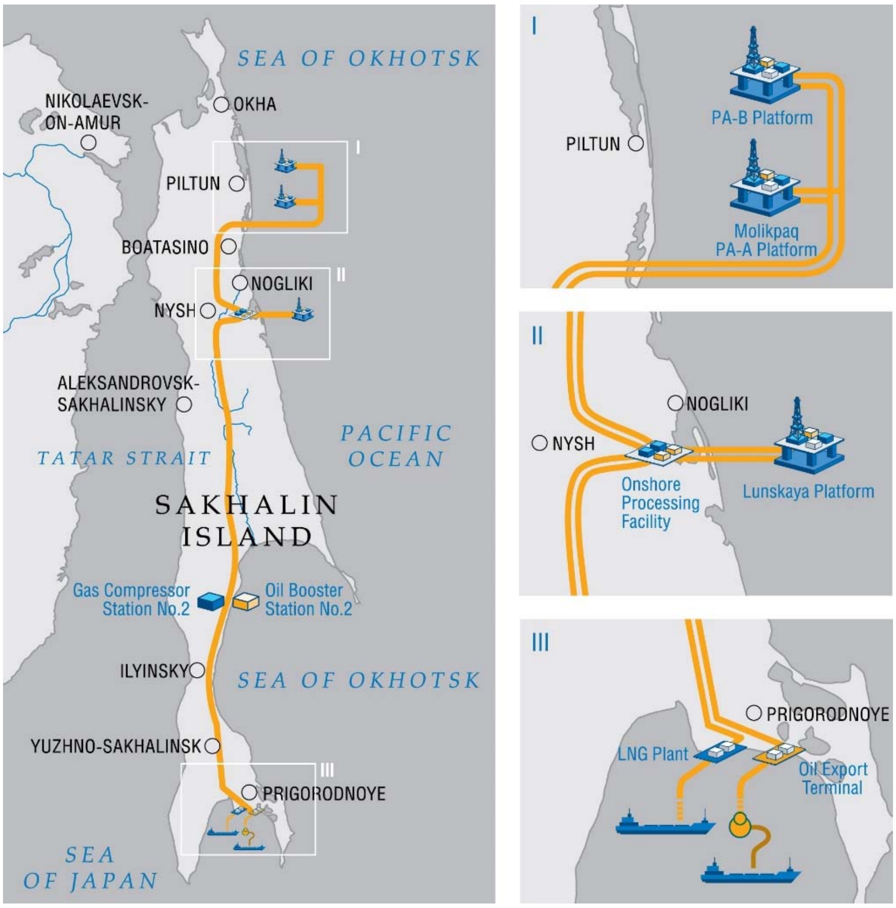

Figure 85. The Sakhalin-2 project location.

The Piltun Astokhskoye oil and gas field:

Piltun Astokhskoye lies 16km offshore Sakhalin Island's north-east shore, in the Sea of Okhotsk. It lies in 30m of water. This field is developed by the Vityaz Production Complex. This consists of the newly refitted Molikpaq, a single anchor leg mooring (SALM) 2km away and a floating storage and offloading vessel (FSO).

The Lunskoye natural gas field:

Lunskoye Oil And Gas Field is 20 km offshore in 50 m water depth. The field was discovered in 1984 and was appraised by seven wells drilled from a mobile rig confirming a large gas accumulation.

<u>Natural conditions:</u>

The natural conditions of the Sea of Okhotsk are the same as for the Sakhalin-1 project, described in Section 3.2.4.1 of the report.

3.2.5.2. Field logistics: offshore/onshore infrastructure

<u>Offshore facilities and sea suppliers:</u>

The project's infrastructure includes three offshore ice-resistant platforms:

- Piltun-Astokhskoye-A platform[100] is the Molikpaq ice-resistant drilling and oil production platform, originally built to explore for oil in the Canadian Beaufort Sea. It had been mothballed in 1990, and was installed in the Astokh area of the Piltun-Astokhskoye field, 16 kilometers (9.9 mi) offshore, on September 1998. The Molikpaq has production capacity of 90,000 barrels per day (14,000 m3/d) of oil and 1.7 million cubic meters of associated gas. Year-round oil production from the PA-A platform was launched in December 2008. Oil from the platform streams through the Transsakhalin pipeline system to the oil export terminal of the Prigorodnoye production complex.

Figure 86. Piltun-Astokhskoye-A Molikpaq oil production platform (Source: Sakhalin Energy).

Figure 87. Prigorodnoye production complex and Piltun-Astokhskoye-A platform (Source: Gazprom.com).

- The Piltun-Astokhskoye-B (PA-B), the largest platform of the Sakhalin-2 project, is a drilling, processing and production platform that has been extracting oil and associated gas from the Piltun reservoir since 2008. The hydrocarbons from the PA-B platform flows through the

[100] Piltun-Astokhskoye-A Platform is available on video https://www.youtube.com/watch?v=JadRUedjEVE

offshore and onshore pipelines to the LNG plant and oil export terminal at the Prigorodnoye production complex. The platform is located 12 km off the northeastern coast of Sakhalin Island, in a water depth of around 30 m. With the topsides installed on the base structure, the total height of the PA-B platform is 121 m from the sea floor to the top of the derrick - as large as a 30-store building. Production capacity: oil approximately 70,000 b/d (11,130 m3/d); associated gas 100 mln scf/d (2.8 mln m3/d)[101].

Figure 88. Piltun-Astokhskoye-B oil production platform (Source: Sakhalin Energy).

- The Lunskoye-A platform is the first in Russia offshore gas production platform. This platform produces the majority of the gas for the LNG plant. Oil/condensate and gas separation including gas treatment for transport to the LNG plant is done at the onshore processing facility. The platform is located 15 km off the north eastern coast of Sakhalin Island, in a water depth of 48 m. The height is 174.5 m, that is higher than the great pyramid of Cheops. The platform includes drilling and gas/hydrocarbon liquids/water separation facilities, storage for chemicals. The living quarters have a capacity for 100 permanent and additional 36 temporary staff. Production capacity: gas – 51 mln m3/d; condensate about 50,000 b/d (8,000 m3/d)[102].

[101] For more information, see http://www.sakhalinenergy.ru/en/company/company_assets/platforma_piltun_astokhskaya_b.wbp
[102] For more information, see http://www.sakhalinenergy.ru/en/company/company_assets/platforma_lunskaya.wbp

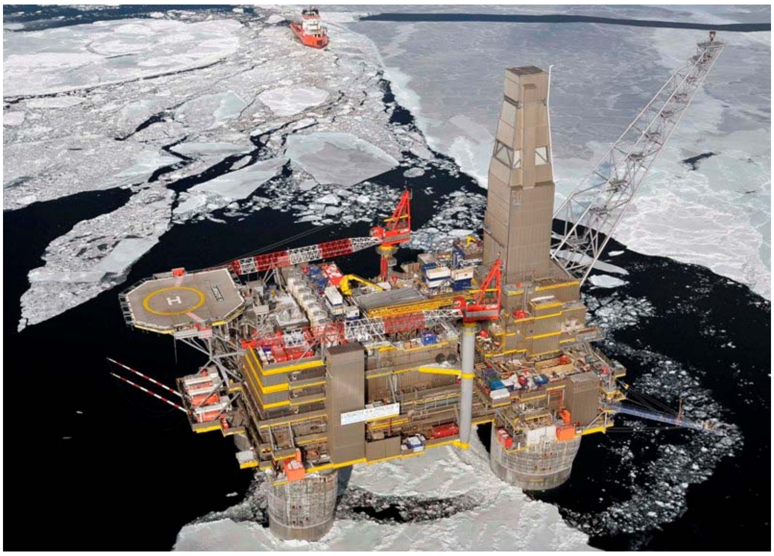

Figure 89. Lunskoye-A gas production platform (Source: Sakhalin Energy).

In addition, Sakhalin-2 includes a pipeline system of 300km of pipes that covers the whole of Sakhalin, and also above-ground gas pipeline and oil pipeline, each 800km long, which connect to an onshore production facility, oil export terminal, and also Russia's first (and so far only) LNG production plant.

Maritime vessel availability:

Currently seven of SCF Group's multi-purpose ice-breaking supply vessels are engaged in the Sakhalin-2 project: "SCF Endurance" (since 2009), "SCF Endeavour" (since 2016), "SCF Enterprise" (since 2016), "Fedor Ushakov" (since 2017), "Gennadiy Nevelskoy" (since 2017), "Stepan Makarov" (since 2017), "Yevgeny Primakov" (since 2017).

Two LNG carriers "Grand Aniva" and "Grand Elena" transport LNG from a terminal in the town of Prigorodnoye (Aniva Bay) in the south of the island to Japan, South Korea and China under long-term contracts with the project operator. Deliveries began in March 2009.

Transportation of crude oil from the Sakhalin-2 project is undertaken under long-term contracts with the project operator, by three of Sovcomflot's ice-class Aframax tankers: "Zaliv Aniva", "Sakhalin Island" and "Governor Farkhutdinov".

Table 16. ***Vessels engaged in the Sakhain-2 project.***

Vessel	Ice class	Characteristics	Additional equipment	Owner	Built	Flag
"SCF Endurance"	ICE-10 Icebreaker, DnV +1A1	Icebreaking platform supply vessel	OIL-REC, 150 evacuees	Sovcomflot	2006 – Aker Langsten, Norway	Russian
"SCF Endeavour"	ICE-10 Icebreaker, DnV +1A1	Icebreaking platform supply vessel	OIL-REC, 150 evacuees	Sovcomflot	2006 – Aker Langsten, Norway	Russian
"SCF Enterprise"	ICE-10 Icebreaker, DnV +1A1	Icebreaking platform supply vessel	OIL-REC, 150 evacuees	Sovcomflot	2006 – Aker Langsten, Norway	Russian
"Fedor Ushakov"	ICE-15 Icebreaker, DnV +1A1	Multifunctional icebreaking stand-by vessel	Winterized Cold, DAT (-35°C), Fire Fighter 1, OIL Rec., 150 evacuees	Sovcomflot	2017 – Arctech Helsinki Shipyard OY, Finland	Russian
"Gennadiy Nevelskoy"	ICE-15 Icebreaker, DnV +1A1	Icebreaking platform supply vessel	Winterized Cold, DAT (-35°C), Fire Fighter 1, OIL Rec., 150 evacuees	Sovcomflot	2017 – Arctech Helsinki Shipyard OY, Finland	Russian
"Stepan Makarov"	ICE-15 Icebreaker, DnV +1A1	Multifunctional icebreaking stand-by vessel	Winterized Cold, DAT (-35°C), Fire Fighter 1, OIL Rec., 150 evacuees	Sovcomflot	2017 – Arctech Helsinki Shipyard OY, Finland	Russian
"Yevgeny Primakov"	ICE-15 Icebreaker, DnV +1A1	Multifunctional icebreaking stand-by vessel	Winterized Cold, DAT (-35°C), Fire Fighter 1, OIL Rec., 150 evacuees	Sovcomflot	2017 – Arctech Helsinki Shipyard OY, Finland	Russian
"Vidar Viking"	Icebreaker 6, DNV ICE-10	AHTS	Winterized	Viking Supply Ships	2001 - Havyard Leirvik AS	Sweden/ Russia
"Zaliv Aniva"	+1A1, ICE-1C	Aframax shuttle tanker (double-hulled)		Sovcomflot	2009 - Hyundai Heavy Industries, Korea	Cyprus
"Sakhalin Island"	+1A1, ICE-1C	Aframax shuttle tanker (double-hulled)		Sovcomflot	2004 - Brodosplit Shipyard, Croatia	Cyprus
"Governor Farkhutdinov"	+1A1, ICE-1C	Aframax shuttle tanker (double-hulled)		Sovcomflot	2004 - Brodosplit Shipyard, Croatia	Cyprus
"Grand Aniva"	+100A1, 1C	LNG carrier		Sovcomflot	2008 - Mitsubishi Heavy Industries, LTD	Cyprus
"Grand Elena"	+100A1, 1C	LNG carrier		Sovcomflot	2007 - Mitsubishi Heavy Industries, LTD	Cyprus

Onshore facilities:

There are several supply bases to provide supply deliveries under “Sakhalin-1” project:

- Kholmsk shore base (founded in 1998) located in Kholmsk Marine Trade Port supports Sakhalin Energy’s three offshore production platforms. The port is able to accept ice-class vessels with 8,5 meters drought. Due to this, the port is able to provide all year round onshore support of “Molikpaq” platform and all oil production complex “Vityaz[103].

Figure 90. The location of the supply shore bases on Sakhalin (Source: Sakhalin-Shelf-Service, LLC).

- Sakhalin Western Seaport (founded in 2002) near Kholmsk settlement is the most modern port on Sakhalin and the only port on the Far East, specialized on supporting oil and gas projects. Since 2005, it has been functioning as unified onshore supply base for “Sakhalin-1” and “Sakhalin-2” projects[104].

Facilities:	- Offices	2000 м^2
	- Warehouses	30000 м^2.
	- Open storage areas	70000 м^2.
	- Berths	1090 m
	- Railway spurs	2,5 km
Main equipment:	- Port cranes, capacity	20 tons.
	- Forklifts, capacity	1,5-23 tons.
	- Mobile cranes, capacity	50-150 tons
	- Port cranes, capacity	32 tons, 60 tons
	- Gantry cranes, capacity	20-32 tons
	- Trucks, capacity	20 tons

[103] For more information, see http://www.sssc.ru/engpage_28.htm
[104] For more information, see http://www.sssc.ru/engpage_29.htm

Figure 91. The Sakhalin Western Seaport on Sakhalin (Source: Sakhalin-Shelf-Service).

- Yuzhno-Sakhalinsk operations base (founded in 1998) maintains equipment and provides cargo transportation, as well as there are hazardous waste (I-IV class) treatment facilities.

Facilities:	- Offices	450 м^{2}
	- Warehouses	4306 м^{2}.
	- Open storage areas	20000 м^{2}.
Main equipment:	- Mobile cranes, capacity	50-90 tons.
	- Forklifts, capacity	3-5 tons.
	- Low boy truck with trailer	75 tons
	- Trucks, capacity	18-42 tons

- Nogliki Supply Base (founded in 2006) provides continuous supply of diesel fuel by trucks for OPF generators, which produce electric power for LUN-A drill platform. There is satellite communication system and 24-hours monitoring system to monitor vehicles' movement. There was developed oil spill response plan for quick oil spill response[105].

Facilities:	- Office	70 м^{2}
	- Warehouse	4660 м^{2}.
	- Open storage area	10000 м^{2}.
Equipment:	- Fuel truck KAMAZ	
	- NEFAZ" bus for crew change	
	- Escort vehicles - Land Cruiser	
	- KAMAZ with oil spill response equipment	

- Wakkanai shore base (founded in 2000) in the Wakkanai Japanese port provides winter parking for rig installations and specialized support fleet.

[105] For more information, see http://www.sssc.ru/engpage_32.htm

3.2.5.3. Emergency preparedness logistics: SAR and oil spill response

Oil Spill Response (OSR) plans for all production facilities are developed and agreed with the authorities.

Non-professional emergency response teams are in permanent readiness:

- at LNG plant;
- at Onshore Processing Facility;
- on Piltun-Astokhskoye-A platform;
- on Piltun-Astokhskoye-B platform; and
- on Lunskoye-A platform.

The management bodies are on duty day and night in case of emergencies and crisis situations: the duty members of the crisis management team and the emergency coordination team. The duty dispatcher service works round the clock.

In accordance with Russian Federation Government Regulation of 21.08.2000 No. 613, revised on 15 April 2002, No. 240, and Ordinance of the Sakhalin Oblast Administration of 10.11.2005 No. 203-pa, the goal of planning of actions for oil and oil product spill response shall be determination of the necessary composition of forces and special technical devices for containment of spills in an offshore area *within 4 hours* after spill detection or obtaining information on a spill, and for organization of subsequent operations response to such spills.

First-priority response actions on facilities are based on the strategy of spill containment and gathering of spilled oil, which suggests:

• deployment of OSR forces and facilities;

• spill containment (booms);

• collection of oil (skimmers); and

• temporary and long-term storage of collected wastes.

OSR actions envisaged by Sakhalin Energy include prompt response actions at the place of spill, actions of onshore-based forces and facilities, and response with participation of additional vessels from the Lunskoye Field.

Oil spill response under ice conditions with ice consolidation factor above 70 % does not require compulsory utilization of special means for spill containment, since this role may be played by ice.

<u>Response offshore:</u>

On the Piltun-Astokhskoye and Lunskoye fields, multi-function support vessels are on twenty-four hour alert, which are complete with equipment or responding in case of emergency events (oil) and manned with qualified personnel trained for performance of emergency rescue operations during emergencies (oil). In case of a spill, supply vessels working in the area of the platforms will come to the aid to the said vessel(s), which may be used for deployment of equipment, both independently and in a couple with multi-function support vessel(s). There is a multi-function support vessel on twenty-four hour alert in the Lunskoye field, equipped, ready to

The list of equipment onboard multi-function support vessels comprises oceanic and arctic containment and oil-collecting systems. There are two different booming systems, i.e. 600 m of Heavy-Duty oil Boom and 75 m of Light Oil Boom. There are four skimmers, i.e. two weir skimmers and two oleophilic brush skimmers at each field.

Response onshore:

Onshore, equipment is placed at PMDs and/or production facilities of the Company. Servicing and repairs of equipment for oil spill response are provided by Sakhalin Energy's OSR contractor. It also draws up annual inventory of this equipment. The location of depots with OSR equipment available at them relative to the Company's facilities is shown in Figure 3, their full list is given below.

- Nogliki PMD (response equipment for onshore and in bays);
- Lunskoye PMD at the OPF site (response equipment for onshore and rivers);
- Yasnoye PMD (onshore);
- Gastello PMD at the Booster Station-2 site (onshore);
- Sovetskoye PMD (onshore);
- Prigorodnoye (onshore and marine); and
- Kholmsk Support Base (marine).

For transportation of equipment into bays that are to be protected in case of oil spill, helicopters are available at the disposal of Sakhalin Energy. The flight time from the settlement of Nogliki to the Piltun- Astokhskoye Field is about 45 minutes. The flight time from the settlement of Nogliki Airport to the Lunskoye field is about 25 minutes[106].

At each PMD, fast deployment packages (FDP) are available. Fast deployment packages consist of light equipment accommodated in 5-ton containers that may be transported by helicopter on a suspended-type lifting gear, by Ural trucks (with trailer), cargo trailers, or by other means of container transport.

In addition, at PMD there are available OSR mobile packages on the base of Ural trucks (OSR MP) and fast response trailers. This equipment is intended for fastest delivery to an oil spill

[106] For more information, see http://www.sakhalinenergy.ru/media/library/eng/Environmental/OilSpillResponse/5.6_LUN-A_OSPR_summary_en_final.pdf

spot for the purpose of providing first-priority actions for oil slick containment. Storage of OSR equipment and tools in the form of fast deployment packages assures prompt mobilization in case of emergency (oil) with a minimum time of loading onto a transport means and delivery.

Deployment of equipment with utilization of motor transport will need about 3 hours (delivery from the settlement of Nogliki to the Chaivo Bay) of 4 hours (delivery from the settlement of Nogliki to the Lunskoy Bay), plus 1 hour for loading operations[107].

Theoretical classes, drills and exercises on emergency response of various levels are conducted regularly.

In October 2017, Sakhalin Energy conducted Oiled Wildlife Response Training. Company provides theoretical and practical trainings of this kind since 2005. This year HSE specialists representing oil and gas companies and competent authorities took part in the exercise. About 300 company employees were trained for over twelve years of wildlife response program implementation[108].

Figure 92. Sakhalin Energy's training in October 2017 (Source: Sakhalin Energy)

[107] For more information, see http://www.sakhalinenergy.ru/media/library/eng/Environmental/OilSpillResponse/5.7_Piltun-Astokhskoye%20Summary_ENG.pdf

[108] For more information, see http://www.sakhalinenergy.ru/en/media-centre/news/item.wbp?article_id=132f951a-6912-4023-a3ed-cb967b2b2100&date=02%C2%A0November%C2%A02017

3.2.5.4. Summary of both cases Sakhalin-1 and Sakhalin-2

Table 17. ***Summary of logistics infrastructure in Sakhalin-1 and Sakhalin-2.***

Project	***Project Operator***	***Investors***	***Field/ contract territory***	***Platform***	***Distance from the shore***	***Oil /gas production***	***Supply vessels & tankers***
Sakhalin-I	Exxon Neftegaz Ltd. (Bahamas)	- Exxon Neftegaz Ltd (Bahamas) (a subsidiary of Exxon Mobil (USA)) – 30% - Consortium SODECO (Japan) – 30% - JSC Rosneft (Russia) acting via its affiliates: RN-Astra (Russia) – 8,5% and Sakhalinmorneftegaz-Shelf (Russia) – 11,5% - ONGC Videsh Ltd. (India) – 20%	Chayvo field	"Orlan"- offshore platform: Weight: 70,000tons Length = 96m Width=89.9m Height=50m "Yastreb" – onshore drilling rig	11 km	Since 2005	"Kigoriak" "SCF Sakhalin" "Vitus Bering" "Aleksey Chirikov" "Tor Viking" Tankers: "Yuri Senkevich" "Viktor Titov" "Viktor Konetsky" "Captain Kostichev" "Pavel Chernysh"
			Odoptu field	Yastreb" – onshore drilling rig		Since 2010	
			Arkutun-Dagi field	"Berkut" offshore platform (installed in 2014)	25km	Since 2015	
Sakhalin-II	Sakhalin Energy Investment Company Ltd. (Sakhalin Energy Bermuda)	- GazpromSakhalin Holdings B.V. (Neverlands),(a subsidiary of JSC Gazprom (Russia)) – 50% + 1 share - Shell Sakhalin Holdings B.V. (Netherlands) (a subsidiary of Royal Dutch Shell plc. (Netherlands/UK)) 27,5% - 1share - Mitsui Sakhalin Holdings B.V. (Netherlands) (a subsidiary of Mitsui and Co., Ltd. (Japan)) – 12,5% - Diamond Gas Sakhalin B.V. (Netherlands) (a subsidiary of Mitsubishi Corporation (Japan)) – 10%	Piltun-Astokhskoye field	Molikpaq (Piltun-Astokhskaya-A) platform	16 km	Since 1999	SCF Endurance SCF Endeavour SCF Enterprise "Fedor Ushakov" "Gennadiy Nevelskoy" "Stepan Makarov" "Yevgeny Primakov" "Vidar Viking" 3 tankers: "Zaliv Aniva" "Sakhalin Island" "Governor Farkhutdinov" 2 LNG carriers
				Piltun-Astokhskoye-B platform	12 km		
			Lunskoye field	Lunskaya platform	15km	Since 2009	

It is worth noting that two vessels owned by Viking Supply Ships have been involved in both projects Sakhalin-1 and Sakhalin-2 from time to time. The interviewee of Norwegian shipping company #1 told what experience the company obtained:

"Since 2012, our two vessels have been conducting ice management and supply operations in the Okhotsk Sea. For example, the gross value of the contract on "Vidar Viking" for providing services in the summer of 2012 was approximately 70 million USD. The contract on "Tor Viking" in 2016 was valued at approximately 45 million USD for six months. It was the first and important experience to operate the vessel under the Russian flag with the Russian crew, using the Russian resources and collaboration with the Russian government. At the same time, we got a very positive experience of our vessels' transit via the Northern Sea Route towards/back Sakhalin projects".

3.2.6. Case 10. Fields in the Laptev Sea

3.2.6.1. **Field location and natural conditions**

General info:

The Tsentralno-Olginskaya-1 well is the only northernmost well in the World located at the bottom of the Laptev Sea (near the Khara-Tumus Peninsula). Rosneft possesses this Khatanga license since November 2015. Oil reserves are estimated at 9.5 billion tons with huge additional gas reserves, as Rosneft's leader Igor Sechin told President Vladimir Putin in early April 2017[109]. Rosneft completed preparations for drilling at Tsentralno-Olginskaya-1 in record-short time. Since 2015 till April 2017, a total of 21,000 meter of seismic studies have been conducted and as many as 114 prospective structures identified.

[109] For more information, see http://xn--b1agjasmlcka4m.xn--p1ai/event/rosneft-nachala-burenie-skvazhiny-centralno-olginskaya-1

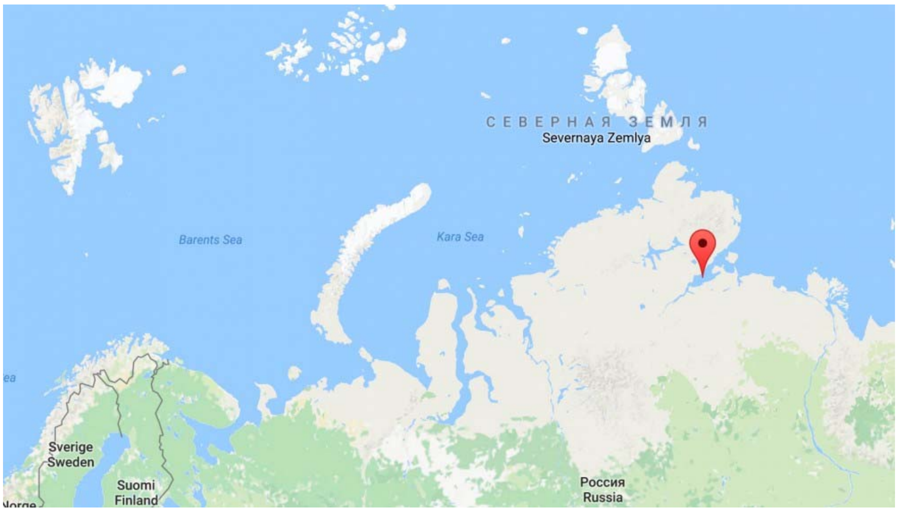

Figure 93. The location of the Tsentralno-Olginskaya-1 well in the Laptev Sea (Source: thebarentsobserver.com).

Figure 94. The location of the Tsentralno-Olginskaya-1 well in Khatanga bay (Source: Rosneft.com).

The well is located 70 meters from the coast, and is to be drilled at an angle of 5 kilometers under the very waters of the bay. Water depths in the Khatanga license area, which is north of the Krasnoyarsk Region, reach 32 m (105 ft).

The Gulf of Khatanga is among the least accessible places in the Russian Arctic. Located east of the Taymyr Peninsula by the ice-covered Laptev Sea, the license area is open for regular shipping only two months in the year. The nearest settlement is Khatanga, a town with a population of about 2,500 located about 350 km to the southwest[110].

[110] For more information, see https://www.rosneft.ru/press/news/item/183143/

Figure 95. Rosneft's drilling operation site at the Tsentralno-Olginskaya-1 well in Khatanga bay in April 2017 (Source: Rosneft.ru).

The Tsentralno-Olginskaya-1 well was drilled from the shore of the Khara-Tumus Peninsula on the shelf of Khatanga Bay. During the drilling operations of the Tsentralno-Olginskaya-1 well in April 2017, three core samples were taken from depths of 2,305 to 2,363 meter. These samples show high oil saturation dominated with light oily fractions (Rosneft press release).

Mastering the resources and even any talk about the mining of minerals in the Arctic is preceded by an extensive scientific study. Before the drilling operations started, Rosneft opened a research station in the area in August 2016. The station was developed as "a research outpost for development and testing of new technology, technical equipment and materials". Research activities have been conducted on site at that same as the oil drilling. The research station is 16 km from the drilling site. 24 people were in the research camp and 20 more in the field expedition on an ice floe of 80 kilometers. If the weather goes bad, scientists from the camp could be evacuated only by helicopter. The team of researchers and Rosneft's specialists spent two spring months at the base to study ice conditions in the area in 2017. A total of 40 drifting buoys were placed on the ice and more than thousand measurements and samples of ice qualities were made, according to Rosneft's press release[111].

"We solve complex problems of interaction between the natural environment and man, because the ice is a carrier platform which absorbs all the information of human activity," said Evgeny Makarov, head of the Khatanga-Zima expedition. *"We study ice as an environment for life because it is a memory of planet Earth and displays all the processes that occur in the air and water environment"*[112].

[111] For more information, see https://www.rosneft.ru/press/news/item/186951/

[112] Available on: http://georgiatoday.ge/news/6295/Russia-Drills-the-Northern-Most-Well-in-the-World

Source of water for drinking, sanitary and household needs is delivered water. Source of water for technical and fire safety needs is sea water (water passes the stage of desalination and water treatment), fresh water from Kutuyikan stream (an additional source of water in the warm period of the year), treated domestic waste water, rain and thawed waters.

Electricity is produced using diesel-generator installations. The heating is provided by a boiler house, heaters on diesel fuel and electric ones.

Natural conditions:

The Laptev Sea has a severe climate with temperatures below 0 °C (32 °F) for more than nine months of the year. Navigation is open only in July until August.

The Laptev Sea has the largest expanse of fast ice in the world from January till June. The fast ice thickness typically reaches 200 centimeters due to mean midwinter air temperature of -30 ^{0}C and can grow up to 250 centimeters during severe winters. The concentration of multiyear ice in the Laptev Sea is limited due to wind directions and ocean currents. The total area of summer melt is particularly extensive due to the reduced concentration of multiyear ice. In the western part, the ice drift is southwards and large masses of ice are deposited along the coast of Severnaya Zemlya and the Taymyr Peninsula[113].

There is an increased refraction, which slightly increases the duration of the day, and a slow change in n the sun's decline above the horizon at high latitudes prolongs twilight. The duration of the polar night increases from 70-80 days in the southern part of the Laptev Sea to 100-120 days - in the northern part. The polar day due to refraction is about 16 days longer than the polar night.

Air temperatures stay below 0 °C 11 months a year on the north and 9 months on the south. The average temperature in January (coldest month) varies across the sea between −31 °C and −34 °C. The minimum is −50 °C. In July, the temperature rises to 0 °C (maximum 4 °C) in the north and to 5 °C (maximum 10 °C) in the south. However, it may reach 22–24 °C on the coast in August.

Strong winds, blizzards and snowstorms are common in winter. Snow falls even in summer and is alternating with fogs. The winds blow from south and south-west in winter with the average speed of 8 m/s, which subsides toward the spring. In summer, the winds change direction to the northerly, and their speed is 3–4 m/s[114].

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[113] Available on:
http://www.arctis-search.com/Natural+Conditions+and+Navigation+through+the+Northeast+Passage

[114] For more information, see “Plan for works on the object: "Program of marine geophysical works on the area of the Laptev Sea in 2013-2014" - Environmental impact assessment” by NefteGasStroy Center LLC, available on http://smng.com/site-specific/smng.com/upload/ovos/laptev-t2.pdf

As told by the interviewee of Russian oil company #2 about the natural conditions during the drilling operations:

"Well, how the Laptev Sea looked like in April – the air temperature reached -40/-45 ^{0}C, the wind was quite strong, 18-20m/s. This weather is really a challenge for both people and machinery. No civilization at all. Reindeer breeders with herds appear here only during the short northern summer, as well as white bears. Now, they prefer to spend time on ice closer to the Northern Sea Route".

2.2.7.2. **Field logistics: offshore/onshore infrastructure**

There are no seaports in the vicinity of the Khara-Tumus peninsula where the drilling operations were conducted. The navigation period in this area lasts no longer than two months a year.

These drilling operations are offshore, but carried out actually by the drilling installation at an angle of five kilometers down, from the shore. Thus, there was no need to mobilize the offshore drilling platform and support of OSVs. That made it possible to reduce costs significantly.

At the same time, the field logistics included unique operations before the drilling started.

The captains and sailors on board vessels, which happen to visit the Khatanga Bay, talk about this place like this: *"To sail in the Khatanga bay means to visit the edge of the map"*[115].

The reason for this saying is that the nearest seaport of Khatanga is located on the right shore of the Khatanga River flowing into Khatanga Bay in the Laptev Sea, 115 miles from the mouth. The port functions only during the summer navigation (from the middle of June until the end of September). Ice covered period is September – May. The port can admit vessels with the draught of up to 4.6m. Loading from sea to river vessels is carried out at the Cape of Kosistiy. The seaport of Khatanga is equipped by 5 berths, 3 floating cranes, 3 crawler cranes, 1 autocrane, 6 forklift trucks and has open-air storage capacity of 17,500 m^2. Commodities and refrigerated cargoes, various general cargoes for the Arctic urban areas, timber and bulk freights (coal, sand and gravel mixtures), and bulk oil cargoes are handled at the port[116]. It is worth noting that every year an ice dam (20 m high and 60 m long) has been built in the port in order to protect the "wintering" fleet and some infrastructure from spring ice fields drifting along the Khatanga River to the Laptev Sea.

[115] Available on: https://www.e-river.ru/uploads/newspaper/paper/230/6233.pdf
[116] For more information, see https://ru.wikipedia.org/wiki/%D0%A5%D0%B0%D1%82%D0%B0%D0%BD%D0%B3%D0%B0_(%D0%BF%D0%BE%D1%80%D1%82)
Some details were used from ESIMO Centre at the Ministry of Transport of Russia at ZAO CNIIMF.

Figure 96. Ice dam in the port of Khatanga in July (Source: http://myphototravel.livejournal.com).

In 2016, during the summer navigation, ice-class vessel “Sevmorput” and one more ice-class vessel delivered more than 8,000 tons of equipment, materials for drilling and technology, including the drilling rig and accommodation modules, from the sea port of Arkhangelsk to the drilling site. They covered the distance of 3,600 kilometers across the areas of the White Sea, the Kara Sea and the Laptev Sea to the remote Khatanga Bay with the icebreaker assistance of “Yamal”[117].

Figure 97. The development of the research base in Khatanga Bay, summer 2016 (Source: Rosneft.ru).

However, ice-class vessels were not able to sail in shallow waters of the Khatanga Bay, and there was a need for using river vessels with light draught of water, which were more maneuverable. In June 2016, two river vessels “Solnechnogorsk” and “Electrostal” were towed by

[117] For more information, see http://xn--b1agjasmlcka4m.xn--p1ai/event/rosneft-nachala-burenie-skvazhiny-centralno-olginskaya-1

icebreaker “Dikson”[118] one by one during ca. 5 days from Yenisey River along the Northern Sea Route via Vilkitsky Strait[119] connecting the Kara and Laptev Seas to the Khatanga Bay. “Solnechnogorsk” and “Electrostal” operated during 1.5 months from August to October 2016. The distance between the sea ice-class vessel and the drilling site was 50-60 km. Loading on the river vessels could reach up to 10 hours, the river vessel's sailing took about 5-6 hours. Unloading from the river vessels to the shore also took about 10 hours[120].

At the beginning of August 2017, “Taymyr” icebreaker provided ice assistance for the vessels sailed to the Laptev Sea for the field operations at Tsentralno-Olginskaya-1[121]: "Grigoriy Shelikhov" and "Ermak", as well as research vessels "Nikolai Trubyatchinsky" and "Geologist Dmitry Nalivkin"[122].

[118] It is worth noting that in November 2017, an experimental 30-kW laser installation was tested on “Dikson” icebreaker, which is able to cut ice up to four meters thick. , which can prolong navigation in the conditions of the severe climate of the Arctic. This innovation has been carried out under the federal target program "Civil shipbuilding" (the 1st author’s note).

[119] Vilkitsky Strait is considered one of the most difficult part of the Northern Sea Route for navigation because the depth is between 32 m and 210 m and it is covered with drifting ice all year round (the 1st author’s note).

[120] For more information, see https://www.e-river.ru/uploads/newspaper/paper/230/6233.pdf

[121] For more information, see http://gazetazp.ru/lenta/32448

[122] Both research vessels were engaged by the Marine Arctic Geological Exploration Expedition, which carried out 13.3 thousand kilometers of 2D seismic surveys for Rosneft in July-October, 2017 in the Kara Sea, Laptev Sea and East Siberian Sea (the 1st author’s note).

Table 18. ***Vessels operated in the Khatanga Bay for the field project "Tsentralno-Olginskaya-1 well" in summer navigations 2016 and 2017 (not OSVs excluding research vessels).***

Vessel	Ice class	Characteristics	Owner	Built	Flag	Navigation period
"Solnechnogorsk"	No ice class; intended for summer navigation	General cargo ship for shallow depth	Yenisey River Shipping - Krasnoyarsk, Russia	1965 – Zavody Tazkeho Strojarstva, Komarno, Slovakia	Russian	Summer 2016
"Electrostal"	No ice class; intended for summer navigation	General cargo ship for shallow depth	Yenisey River Shipping - Krasnoyarsk, Russia	1965 - Slovenske Lodenice - Komarno, Slovakia	Russian	Summer 2016
"Dikson"	Icebreaker: RMRS[123] L4 (ICE-C, Ice 1)	Tug icebreaker	Rosmorport, Arkhangelsk	1983 - STX Helsinki, Finland	Russian	Summer 2016
"Sevmorput"	RMRS UL (DNV ICE-1A*)	General cargo container vessel	FSUE Atomflot	1988 - Zaliv Shipyard, Kerch, Ukrainian SSR	Russian	Summer 2016
"-" (no data)	High ice class	Container vessel - from Arkhangelsk port with major equipment	-	-	Russian	Summer 2016
"Yamal"	Arktika-class icebreaker; RMRS Icebreaker9	Icebreaker; helipad and hangar for one helicopter: Mi-2, Mi-8 or Ka-27	FSUE Atomflot	1992 – Baltic Shipyard, St. Petersburg	Russian	Summer 2016
"Grigoriy Shelikhov"	No ice class	General cargo vessel	Spliethoff´s Bevrachtingskantoor - Amsterdam, Netherlands	1992 - IHC Holland Sliedrecht	Russian	Summer 2017
"Ermak"	No ice class	General cargo vessel	Khatanga Maritime Trade Port – Khatanga, Russia	1999 - Malta Shipyard - Marsa, Malta	Russian	Summer 2017
"Taymyr"	Polar 10	Helipad, hangar for one KA-32 helicopter	FSUE Atomflot	1989 - Wärtsilä Marine, Helsinki Shipyard, Finland; Baltic Shipyard, Leningrad, Soviet Union	Russian	Summer 2017

According to the Head of Rosneft, the logistics operation and preparation required a lot of efforts and time before the drilling operations started in April 2017:

"*The results of our studies have shown that the deposit at the Khatanga licensed site is unique by its high hydrocarbon content and productive bed thickness. Since offshore operations have been conducted from the shore, there is no need to use the fleet of OSVs. This significantly reduces exploration costs. However, the remoteness of this site, I would say rather the isolation,*

[123] RMRS means the Russian Maritime Register of Shipping that maintains a ship register of the Russian Federation, based in Saint Petersburg, and is a marine classification society.

from the infrastructure and civilization required a serious and too long preparation. Logistics operations for the delivery of the necessary equipment and materials have been complex and lengthy. For example, the delivery of major equipment and accommodation blocks took 8 months to be prepared for one-month drilling operations in April 2017. In addition, all maritime deliveries to this area have been carried out under the legislative norms for navigation in the waters of the Northern Sea Route that it requires the icebreaker assistance and permissions for sailing of freighted vessels. At the same time, due to the huge remoteness, we gained a very good experience of setting up and settling the first year-round research base in the Arctic region located in the proximity of the drilling site in Khatanga bay"[124].

2.2.7.3. Emergency preparedness logistics: SAR and oil spill response

The analysis of the risk and impact of potential emergencies was made by Rosneft. Oil spills at sea have been not expected, because drilling operations are carried out from the shore, according to the project documentation "Environmental Impact Assessment, Non-Technical Summary, 2017"[125]. In accordance with the requirements of MARPOL 73/78, all vessels used have appropriate equipment for oil spill response to prevent the pollution of the marine environment by oil products.

It is worth adding that until July 06, 2017, Rosneft conducted an open tender for services and proposals for the response and liquidation of oil spills during the development of the Tsentralno-Olginskaya-1 well. This lot was intended for the East Siberian branch of RN-Burenie LLC. The price of this lot is 2373510.95 roubles[126] or about 42,000 USD.

In order to ensure offshore operations in the Laptev Sea, being safe and friendly to the environment, and prevent any emergencies in harsh weather conditions, Rosneft organizes special expeditions to investigate the morphometric and dynamic parameters of the ice cover and the internal structure of hummocks. These studies are helpful to increase knowledge and develop experience for future offshore operations how to make them safe and more efficient in ice conditions.

During two months in spring 2017, ice-exploration expedition "Khatanga-Winter 2017" organized by Rosneft together with the Arctic and Antarctic Research Institute and Arctic Research Centre completed field studies in the Khatanga Bay and the southern part of the Laptev

[124] For more information, see https://www.rosneft.ru/press/today/item/187017/
[125] Available in Russian on http://hatanga-well.ecoalliance.ru/wp-content/blogs.dir/37/files/hatanga-well_kpz_2017.pdf
[126] Available on: http://zakupki.rosneft.ru/node/325479

Sea. A comprehensive study of the Arctic region was conducted for the first time at the newest year-round scientific and research base of Rosneft located on the shore of the Khara-Tumus Peninsula in the Khatanga Bay of the Laptev Sea. 40 drifting buoys were set upon the ice. The researchers used a helicopter Mi-8MTB, as well as unmanned aerial and underwater vehicles like drones.

Figure 98. Ice-exploration expedition "Khatanga-Winter 2017" by Rosneft (Source: Rosneft.ru)

The research was conducted at 40 ice bases. Within the expedition framework 23 hummocks and 17 stamukhas were explored, over a thousand assessments of ice structural behavior were performed, 80 core samples of ice were taken in order to determine its physical properties[127].

[127] "Khatanga-Winter 2017" was actually the third ice-exploration expedition of the Company to the Ust-Olenek and Ust-Lensk licence areas and the first one to the Khatanga licence area. For more information, see https://www.rosneft.com/press/news/item/186955/

4 THE HIGH ARCTIC FIELD LOGISTICS INFRASTRUCTURE

4.1 Overview of the cases.

In Section #3, we presented 10 specific cases of the field development projects in order to reveal the logistics infrastructure, offshore and onshore facilities, main features and challenges the companies face when managing maritime logistics operations at various Arctic localities (including two cases of sub-Arctic) and ensuring SAR and emergency preparedness in demanding waters:

- Four cases in the Norwegian Barents Sea (North/South);
- Four cases in the Russian Arctic Seas: the Pechora Sea, the Kara Sea, the Laptev Sea;
- Two cases in the Russian sub-Arctic: the Sea of Okhotsk[128].

The summary table of the case data illustrates briefly each of the cases presented in the report (see, Table #19). We have divided them into two categories:

- *Exploitation* category includes those cases that produce oil and gas: the Goliat project, “Prirazlomnaya” platform, Sakhalin-1 and Sakhalin-2;
- *Exploration* category includes those cases that experienced drilling operations: Johan Castberg project, Korpfjell project, Wisting Central III, Universitetskaya-1 well, Dolginskoye field, Tsentralno-Olginskaya-1 well.

Exploitation

There are very few oil and gas producing facilities in the Arctic or in similar conditions like sub-Arctic areas: the Goliat project, “Prirazlomnaya” platform, Sakhalin-1 and Sakhalin-2 projects. It is also worth noting that the Barents Sea is the most promising area for petroleum development; the Pechora Sea is more challenging, but still promising; the Kara, the Laptev and the East-Siberian Seas are extremely challenging, although the Kara Sea is very rich for hydrocarbons; the Sakhalin area is seismically active zone. While the Goliat project is located in the most favorable zone, the localities of three other exploitation cases like Prirazlomnaya platform, Sakhalin-1 and Sakhalin-2 are characterized by extremely harsh climatic conditions for offshore activities where the ice period lasts from November/December to May/June. In addition, both Sakhalin projects are in a zone of magnitude 6.4 – 7.6 earthquakes.

[128] We took these two cases for consideration in this report because their location in the Sea of Okhotsk experiences more dynamic ice conditions, including hurricanes, severe storms and seismic activity, than many offshore areas north of the Arctic Circle.

From the interviews with the respondents, we have identified two issues related to exploitation operations in the Arctic icy waters:

1. *Loading/Offloading operations:*

In Arctic harsh conditions, the access to the platform by OSVs can be challenged by ice drifting, wind above limits or wave heights, especially in autumn and winter period. There is a need to ensure access for the tankers to the platform or offshore oil terminals.

The ice drift is affected by the direction of the current. Around the Prirazlomnaya platform, a wide ice-free zone is formed behind the platform along the direction of the current (See Figure 99). The tankers use this pass to avoid large ice loads while offloading oil.

Figure 99. An ice free zone behind the Prirazlomnaya platform (left) and offloading operation (right) (Source: Gazpromneft Shelf).

However, the wind can easily change the ice drift direction. According to the interviewee of Russian oil company #3,

"The Prirazlomnaya platform has only two offloading centers at opposite corners of the platform. They are along the direction of the current to make offloading operations safe, but the wind force can change ice drifting in direction of the wake behind the platform. That can create some difficulties or even possible emergencies".

Thus, the offloading operation can be done only when the wake is at the side of offloading centers (see Figure 99, right).

2. <u>*Ice rubbling:*</u>

The ice is often accumulated at one side of the platform hull consolidating and forming ice rubble that can impede the vessels ability to get close to the platform (see Figure 100).

"Actually, it is quite hard to remove the ice rubble because it is formed again and again. It creates delays as the OSVs are not able to get close to the platform. The length of the cargo cranes is limited (for example, around 50 m) and the width of the ice rubble could be the same. Lifting cargo from the vessels can be difficult and risky", as told by the interviewee of Russian oil company #3.

Figure 100. Ice rubbles in front of the Prirazlomnaya platform (Source: Gazpromneft Shelf).

At the same time, the ice rubbles increase the loads on the platform structure and can reduce horizontal stability of the platform. Thus, the shape of the platform in Arctic waters should make it possible the ice rubbles flush by currents and ice drift like the structure of the platforms in Sakhalin-1 and Sakhalin-2 projects.

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In table #19 we have emphasized the main transport challenges and challenges to SAR and oil spill response related to each case. We have also cited the respondents' main experience gained during participation in the development of the offshore operations related to each field case (see the last line in Table #19).

The respondents specifically highlighted the following challenges in their work:

1. Arctic harsh climate:

- *"The extreme weather conditions even in summer time is a real challenge. There are polar lows, a lot of fog, which limits visibility. This may disrupt the regular supply of the rig/platform and complicate navigation"* - the interviewee of Norwegian shipping company #1.
-
- *"We work in harsh weather and ice conditions at the Prirazlomnaya platform. Moreover, the platform is located far from the onshore supply base"* – Official within oil and gas company logistics department[129].

- *"One of the most specific challenges in the Arctic is the ice! I think that we need to find a solution on how to deal not with the Arctic, but the icy waters. How we deal with the ice it is still a challenge without a solution!"* - the interviewee of Russian oil company #2.

2. Distances:

- *"The long distances is the major issue in the Arctic and the sudden change of the weather"*- the interviewee of Norwegian shipping company #2.

- *"The distance to the supply base is a real challenge to organize regular supply deliveries through the ice in Arctic waters, especially when it comes to personnel transportation by helicopters. You are more reliant on larger transport capacities on the vessels so that the long distances might be overcome"* – the interviewee of Norwegian shipping company #1.
- *"The main risks for the offshore northern projects are long distances and remoteness. This challenge requires a lot of preparations including field analyses and logistics planning. It takes too long time to meet all requirements and arrange the schedule of the vessels and helicopters"* – the interviewee of Norwegian oil company #1.

[129] Available at: https://rogtecmagazine.com/gazprom-neft-arctic-routes2/

3. Lack of infrastructure:

- *"Limited infrastructure adds complexity to logistics schemes development. There are just a few Northern ports. The facilities are limited. So, if you have some technical problems, the distance is much longer, and it takes time to get maintenance and transport support in Arctic waters"* - the interviewee of Norwegian shipping company #1.
- *"Communication in the High Arctic is a challenge! The reason for that is because you have much lower pending use when operating in the High North. There are limitations on satellite communication. Today you require much more data to know the transport location solutions…It can be difficult to keep up a good communication between all players involved – from rigs, shore, the vessels and so on"* - the interviewee of Norwegian shipping company #1.

4. Lack of experience:

- *"One of the main weaknesses is the lack of experience of operating in the northern areas. The Arctic is a new area where all players have little experience. If something happens, how to handle it?"* - the interviewee of Norwegian shipping company #2.

- *"Operating in the Arctic waters implies a combination of the vessel power and the crew onboard. So, the crew's qualifications and experience gained from working in the ice are valuable, especially, to ensure safety of operations and life onboard. At the same time, it's too expensive and difficult to organize trainings in the real Arctic conditions for hundreds of personnel. As a result, there are a number of operators who invest in an Arctic project, but have never been there before. For instance, we got a call from a Norwegian ship-owner who provided the Prirazlomnaya platform with the supply vessels like: "We have ice around the ship. What are we going to do?" They did not know what to do because they had not operated in the ice before. They woke up one morning and were surprised by seeing the ice around the ship. That's an example, but it is a challenge that there is a huge lack of experience of operating in the Arctic ice conditions"* - the interviewee of Norwegian shipping company #1.

- *"We like when our vessels equipped for harsh cold-climate conditions get work in the Barents Sea. It means that the vessels use all their capabilities like ice class, anti-icing systems and special equipment available onboard. Also, our employees and the crews gain experience of working in harsh conditions. However, it is difficult to win any contract to operate in the Norwegian Barents Sea. We have found a lot of improvements on the* *logistics side by all oil companies for the last five years. However, there is still a huge lack of crews' experience on working in the polar lows and darkness, because there is a limited number of operations in the northern Barents Sea. At the same time, there are too many vessels in the market"* – the interviewee of Norwegian shipping company #2.

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- *"Oil companies lack experience specifically to manage operations in Arctic waters. It is quite a different task to operate being surrounded by the Arctic ice compared with the traditional conditions in the North Sea! If oil companies aim at operating in Arctic waters, they need to reconstruct their management systems to be flexible and innovative enough"* – the interviewee of Norwegian shipping company #2.

- *"During the Kara Sea operations in 2014, we realized how difficult it was to manage all operations in such difficult conditions. It must be noted that this was in the summer period. Though we got a great experience then, we looked like "dummies" to learn – not so good qualification and past experience at all to work among ice flows. In recent years, we have conducted several summer expeditions in the Kara Sea to develop our experience in the field of ice management, as well as to increase the experience and qualifications of our employees to work in hard-to-reach Arctic waters, especially in the harsh winter conditions of the polar night and ice. We assure that this experience and tests in real ice conditions will allow in the future to increase emergency preparedness of marine infrastructure when performing our Arctic offshore projects"* – the interviewee of Russian oil company #2.

The respondents singled out several challenges categorized in the table. They have specifically emphasized the lack of experience of managing offshore field operations in Arctic remote and icy waters. Respondents have indicated that this lack of experience is critical for safety, and for the emergency preparedness and oil spill response.

Summary* Table 19. *Overview of the case data.

	Exploitation				***Exploration***					
	Goliat, Norway	**Prirazlomnaya platform, Russia**	**Sakhalin-1 Russia (PSA)**	**Sakhalin-2 Russia (PSA)**	**Johan Castberg, Norway**	**Korpfjell PL859, Norway**	**Wisting Central III, Norway**	**Universitetskaya-1 well, Russia**	**Dolginskoye field Russia**	**Tsentralno-Olginskaya-1 well Russia**
Stakehol-ders	ENI Norge (65%) - operator; Equinor Petroleum (35%)	Gazpromneft Shelf - operator	Exxon Neftegaz (30%) – operator; SODECO (30%); Rosneft (20%); ONGC Videsh (20%)	Sakhalin Energy – operator: Gazprom Sakhalin Holdings (50% + 1 share); Shell Sakhalin Holdings (27,5% - 1share); Mitsui Sakhalin Holdings (12,5%); Diamond Gas Sakhalin (10%)	Equinor (50%) – operator; ENI Norge (30%); Petoro (20%)	Equinor (30%) – operator; Chevron (20%); Conoco Phillips (15%); Lundin (15%); SDØE (20%)	OMV(25%) – operator; Petoro (20%); Idemitsu (20%); Tullow (20%); Equinor (15%)	Rosneft (51%); Exxon Mobil (49%) (by joint venture “Karmornefte-gaz”)	Gazprom Neft-Sakhalin, LLC	Rosneft
Start of operations	2000	2013	2005	1996	2018 planned	2017 drilling: August	2017 drilling: August	2014 drilling: July-August; (2019 planned)	2014 drilling: July-August	2017 drilling: April - June
Production start	Since 2016	Since 2014	Since 2005 (Chayvo field); Since 2010 (Odoptu field); Since 2015 (Arkutun-Dagi)	Since 1999 (Piltun-Astokhskoye field); Since 2009 (Lunskoye field)	-	-	-	-	-	-
Location	The Barents Sea	The Pechora Sea	The Sea of Okhotsk		The Barents Sea	The Barents Sea	The Barents Sea	The Kara Sea	The Pechora Sea	The Laptev Sea
Water depth	341 m	19-20 m	about 50 m	50 m	360-390 m	253 m	394.5 m	81 m (straight well depth 2,113m)	40-55 m	32 m
Ice conditions	No ice, iceberg availability during winter; Icing; Heavy snow falls	Ice period during November-June; Average drifting ice thickness 0.8m (max.1.45m); Hummocks	Ice thickness average 1.5 m from December to May; Ridges of compressed ice; Icing from October until December		No ice; Heavy snow fall; icing	Occurrence of sea ice (during ca.10 days); Occurrence of icebergs; heavy snow fall, Icing	No ice; heavy snow fall, icing	Ice period during mid of September- July with close drifting ice; Navigation season August-September; Average ice thickness 1.8m up to 2.5-3.0 m (north-east); Ice ranges thickness 1.2-1.6 m; Hummocking – above water 10-15m, under water 20-25m	Ice period during November-June; Average open water 110 days; Average ice thickness 1.3m	Ice period is almost the whole year (minimum in September)
Weather conditions	Average temp. 0^{0}C/+2.7^{0}C; Average January air temp.-15^{0}C; Polar lows;	Average February temp. -17.4^{0}C (min. -48^{0}C); Average July t=+6.5^{0}C (max.+26^{0}C);	Winter temperature can drop to -45^{0}C; with high humidity and a wind-chill down to -70°C; Seismic zone (6.4 & 7.6 in the past 15 years); Polar lows,		Sea temp. above +1^{o}C; Wind speed 2-15 m/s; Polar lows, fogs	Average January sea temp. 0^{0}C; Average wind speed 8.3 m/s;	Sea temp. above +1^{o}C; Wind speed 2-15 m/s; Polar lows	Air temp. below 0^{0}C 9-10 months (northern Kara Sea), 7-8 months (southern Kara Sea). Average January temp. -20 ^{o}C /-28 ^{o}C (minimum up to -50^{0}C);	Minimum air temp.= -48^{0}C; Maximum summer temp.=+26^{0}C; Wave height: 3.2-4.7 m	Average summer temp.=+5^{0}C/+7^{0}C; Average winter temp.=-35^{o}C/ -37^{o}C up to -60^{0}C

	Average wind speed 27 m/s; Average wave height 2 m	Wave height: 3.2-4.7 m (extreme up to 11.5m)	Storm waves and sea agitation in autumn/winter			Wave height ab. 2.1m (extreme up to 13.8m)		Average July temp. -6 ºC /+1 ºC (maximum +16 ºC); High humidity; July-August: maximum fog and low visibility		
Distance from the shore	88 km	60km	11km Orlan platform 25 km Berkut platform -	16km Molikpaq (Piltun-Astokhskaya-A) platform 12km Piltun-Astokhskaya-B platform 15km Lunskaya platform	50 km	415 km from the Norwegian shore; 37 km from the Russian border	315 km	250 km	90 km	70 meters
Distance from the supply base	88km from Hammerfest	980km from Murmansk	no data	no data	About 240km from Hammerfest	About 570 km from Hammerfest	315 km from Hammerfest	Over 1,600 km from Murmansk	About 960 km (Murmansk); 780km (Arkhangelsk)	350km from the nearest settlement Khatanga; 3,600km from Arkhangelsk
Infrastructure										
Number of OSVs	3 OSVs	3 OSVs; 1 stand-by vessel; 1 icebreaker	4 OSVs; 1 rescue vessel	8 OSVs	1 OSV; 1 stand-by vessel - as assumed	2 OSVs; 1 stand-by vessel; 1 shared emergency vessel from Goliat project	4 OSVs	11 OSVs; 1 rescue vessel; 2 icebreakers; 1 chemical tanker	3 OSVs+ 1 rescue vessel	No OSVs; 4 general cargo shallow ships; 3 icebreakers; 2 ice-class container vessels via the NSR
Number of helicopters used	1SAR + 1transport helicopters	4 helicopters	1SAR + 1transport helicopters	1SAR + 1transport helicopters	1SAR + 1transport helicopters	1SAR + 1transport helicopters	1 SAR helicopter	Not allowed to use	1 SAR helicopter; no data about transport helicopter	no data
Number of tankers	3 shuttle tankers	2 shuttle tankers	5 Aframax tankers	3 Aframax tankers; 2 LNG carriers	No oil production yet					
Transport challenges	Polar nights, Wind, storms; Icing	- Remoteness for regular support; - Ice drifting; - High waves; - Insufficient railway capacity in Murmansk port; - Leasing warehouses;	- Ice drifting, - Ice thickness up to 2m; - Wave height up to 19m, - Seismic zone		- Long distance – 10h by a supply vessel, - Polar lows, fogs; Lack of infrastructure; -Polar nights	- Long distance, - Wind high speed; - Lack of infrastructure	- Dense fogs; - Polar lows; - Long distance; - Lack of resources	- Extreme remoteness (3,5 days of sailing from Murmansk); - Fogs; - Squally wind; - Ice drifting; - Polar nights; - Special regulation in waters of the NSR: icebreaker escort & permissions	- Ice drift, shallow water, wind, waves, polar lows; - Insufficient capacity of railway in Murmansk port	- Extreme remoteness from supply bases; - Long distance; - Supply deliveries during summer navigation; - Escort by atomic icebreakers; - Specific regulation on the NSR

		- Leasing the airport in Varandey							
Challenges to SAR & oil spill response	- Close to the coast due to very short drifting time in this area; - Long response time for resources from the Norwegian Sea and North Sea; - Light conditions (polar nights); - Icing	- Close to the national parks; - Long response time for resources from Murmansk; - Ice drifting; - High waves; - Ice rubble formation; - Polar nights	- Fast changes of ice conditions; - Seismic zone;	- Limited preparedness in Svalbard; - Remote location from onshore resources like helicopters and hospitals; - Polar nights	- Remoteness from the coast - Fogs	- Remoteness: appr. 4hours to Tromsø hospital; - Long periods of dense fogs; - Polar lows; - Sparse metocean data; - Helicopter restriction	- Ice masses drift & Icebergs; - Constant change of weather/ice conditions; - Long distance to the shore and supply base; - Poor communication & JPS signals; - Magnetics; - Complicate to predict exact vessel speed and sailing time; - In case of oil spills, no good solution how to treat it in ice; - No vessel to collect oil in ice today	Remoteness, Sea depth variations, Ice drifting, Currents, Waves	- Extreme remoteness; - Low temperatures - polar lows - Communication; - Lack of infrastructure and experience; - Polar nights
Main experience (the interviewees)	*"Planning is much more essential in the Barents Sea than in the North Sea"* – Norwegian shipping comp.#2	*"At first, it was a great challenge to ensure regular support of the platform due to changing harsh weather conditions, ice drifting and long distance to the onshore supply base"* – Russian oil company #3	- *"We got a very positive experience of our vessels' transit via the Northern Sea Route towards/back Sakhalin projects"* – Norwegian shipping company #1. - *"It was the first and important experience to operate the vessel under the Russian flag with the Russian crew, using the Russian resources and collaboration with the Russian government"* – Norwegian shipping company #1	- *"The logistics solutions are the main driver for cost-effectiveness of the project"* – Norwegian oil company #1	- *"To elaborate the logistics scheme and emergency preparedness for so remote area from the shore requires long preparations and efforts"* – Norwegian oil company #1. - *"It was the first and positive experience of sharing the SAR helicopter with ENI and the Goliat's vessel in the case of possible oil spills"* – Norwegian oil company #1	-	- *"The logistics was maybe where we didn't actually provide the best service. It was a lot of failing and learning during those operations. The logistics could be more efficient what we plan to improve in the next campaign in 2019"* – Norwegian shipping company #1 - *"The most important experience was how to operate in a very short operating window, trying to identify when the ice melts and when the ice freezes again. It was a crucial learning from the operation to identify when is the earliest point of time you can start and when is the latest point of time you have to leave the area"* – Norwegian shipping company #1.	"*We learned how it is difficult to organize the full-fledged operation in a very short operating window of 2014 until ice. During four months, it's necessary to deliver the drilling platform to the field, install it, drill an exploration well, test it and have time to eliminate or conserve it before the first ice comes. This considerably increases the cost of exploration*" – Russian oil company #3	- *"In order to prepare for one month drilling operation, the logistics operation took 8 months to deliver 8,000 tons of equipment and materials"* – Russian oil company #2. - *"It was good experience to use the first year-round research base in the Arctic region located in the proximity of the drilling site in Khatanga bay"* – Russian oil company #2.

*Some explanation to Summary Table #19:

Five columns marked in green represent the Norwegian cases located in the Norwegian Barents Sea.

4.2. Demand for supply services

The OSVs engaged in the field projects in the Norwegian Barents Sea.

The Norwegian offshore fleet is generally presented by a large number of companies compared with the Russian one, e.g. DOF Subsea, Esvagt, Havila Shipping, REM Offshore, SIEM Offshore, Troms Offshore, Viking Supply Ships, and others[130].

Based on the cases, presented in the report, Table #20 provides an overview of the type of OSVs, used by oil companies for the implementation of offshore field operations in the Norwegian Barents Sea.

Table 20. ***The type of OSVs engaged in the field projects in the Norwegian Barents Sea.***

Owner	Vessel name	Flag	Built	Ice class	Type	Emergency preparedness equipment	Project
Esvagt	"Esvagt Aurora"	Denmark	2012	DNV Ice-1C; +1A1	Multifunctional supply vessel	oil detecting radar; IR cameras, winterized, Fire Fighting 1, 320 evacuees	Goliat project
Simon Møkster Shipping	"Stril Barents"	Norway	2015	+1A1	Supply/standby vessel	NOFO2009; oil detecting radar, IR cameras, 240 evacuees+ hospital on board	
DOF Group	"Skandi Iceman"	Norway	2013	DNV Ice-1B; +1A1	AHTS	FiFi I+II, NOFO 2009; winterized, oil.rec., 300 evacuees	
Havila Shipping	"Havila Troll"	Norway	2003	DNV Ice-1C; +1A1	Standby vessel	FiFi I; oil detecting radar, IR cameras, winterized, 320 evacuees	Korpfjell project (2017)
Troms Offshore	"Troms Arcturus"	Norway	2014	DNV Ice-1C, +1A1	Platform supply vessel	NOFO 2009, oil.rec., winterized, 150 evacuees	
GulfMark Rederi, AS	"North Cruys"	Norway	2014	Ice-1B	Platform supply vessel	OIL-REC., NOFO2009, Oil- and Ice-radar, Winterized, 300 evacuees	Wisting
	"North Barents"	Norway	2013	Ice-1B	Platform supply vessel	OIL-REC., NOFO2009, Oil- and Ice-radar, Winterized, 300 evacuees	Wisting
"K" Line Offshore AS (Kawasaki Kisen Kaisha)	KL Sandefjord	Norway	2011	DnV +1A1	AHTS	ROV, Hospital 1	Wisting
	KL Saltfjord	Norway	2011	DnV +1A1	AHTS	ROV, Hospital 1	Wisting

When developing field projects on the Norwegian continental shelf in the Barents Sea, oil companies prefer to utilize pure specialist vessels, which provide a wide range of specific

[130] For more information, see http://offshore-fleet.com/data/companies-norway.htm

functions. According to the interviewee of Norwegian oil company #1, *“We have just to allocate the right vessel to the right job”.*

As presented in Table #20, “Esvagt Aurora” is the only multifunctional vessel, which has been engaged in the Goliat project.

“The fields in the Norwegian Barents Sea are very vast and far away from the shore. They need the support of different types of vessels to perform various offshore operations” – as emphasized by the interviewee of the Norwegian vessel-designer.

He also identified the following issue in specialized shipbuilding:

“There are specific requirements for the vessel design in the area with harsh conditions. At the same time, we learn a lot by collaborating with the customer on the development of the vessel design for an area where the vessel will operate. I think that the vessels must be more purposeful for the areas where they are used. That’s why it is so important to discuss with oil companies what kind of operations and demands, and limitations they face to operate in order to avoid design uncertainty in building specialized vessels for offshore oil and gas exploration. It can happen, e.g., due to possible unsystematic customer input”.

<u>The international OSVs engaged temporally in drilling operations or as extra support in winter navigation on the Russian Arctic shelf:</u>

Table #21 presents the OSVs, owned by international companies (mostly by Norwegian ones) on the Russian Arctic shelf. These OSVs were involved temporarily in operations at different Russian field projects we investigated in this report. Most of the OSVs listed in Table #21 participated in drilling operations in 2014 within the field projects - Universitety-1 well and Dolginskoye field. There are three vessels in Table #21, namely “Balder Viking”, “Vidar Viking”, “Tor Viking”, which provided services as an extra support to the existing fleets for the projects: Prirazlomnaya platform, Sakhalin-1, Sakhalin-2.

As commented by the interviewee of Norwegian shipping company #1,

“ “Balder Viking” provided services of ice-management at the Prirazlomnaya platform for two winter seasons in 2013 and 2015 (from December/January till May). The ice-management at Prirazlomnaya has been challenged because they have regularly loading/offloading operations of oil tankers. In case of ice drifting and ice building up alongside the platform, the operations can be delayed. The contract was initiated by GazpromNeft-Shelf (operator). They needed our vessel because the icebreaker was going to maintenance, docking additional tonnage during those winter periods. In 2018, “Balder Viking” is going to continue providing its services for the Prirazlomnaya platform”.

Vessel “Tor Viking” provided two kind of services simultaneously: for anchor handling and ice-management as operations for ice-charts and ice removing on board the vessel in the period of 2012-2014 in the Sakhalin-1 project.

Since 2012, “Vidar Viking” provided two tasks in the Sakhalin-2 project: 1) supply operations in summers for three platforms - Molikpaq (Piltun-Astokhskaya-A), Piltun-Astokhskaya-B and Lunskaya-A; and 2) winter watch during 2014-2016 at the platform Piltun-Astokhskaya-B as the most northern platform among others in Sakhalin-2.

Photos from winter watch by “Vidar Viking” in the Sea of Okhotsk at Piltun-Astokhskaya-B (April 2013):

Figure 102. Winter watch in April, 2013 (Source: vikingsupply.com)

Figure 101. Vessel icing in January, 2014 (Source: vikingsupply.com)

In order to reach Sakhalin projects, both vessels “Vidar Viking” and “Tor Viking” experienced several transits via the Northern Sea Route[131].

[131] Also towards/back Alaska in 2007, 2010, 2012 when “Tor Viking” was working for Shell’s project in the Beaufort Sea and Chukchi Sea because the shorter distance instead of via Panama from Seattle to Sweden 9,500-7,400=2,400nm, as well as good experiences with previous transits via the Northern Sea Route (from the interview with the representative of Viking Ice Consultancy).

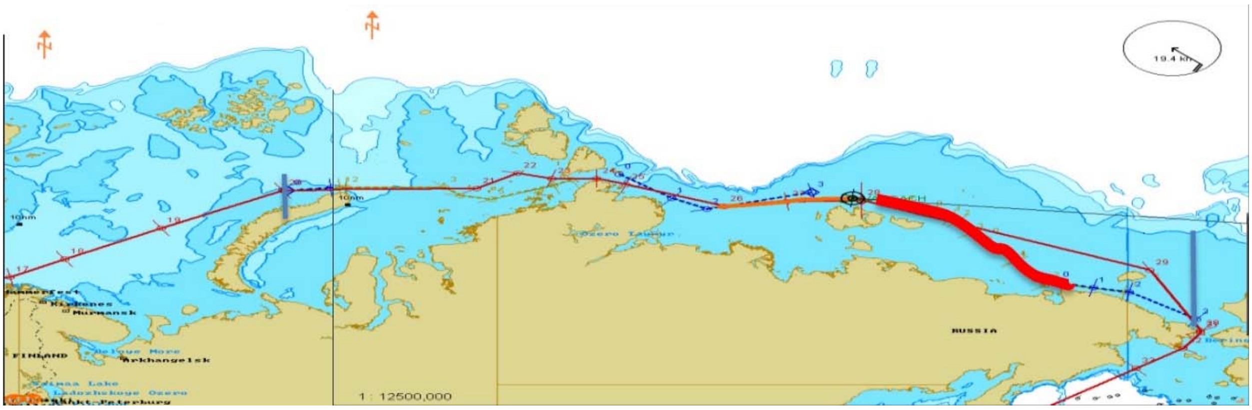

Figure 103. Transit of "Tor Viking" via the Northern Sea Route during the summer navigation in 2014 (Source: vikingsupply.com)

According to the interviewee of Norwegian shipping company #1,

"We got very positive experience of our vessels' transit via the Northern Sea Route towards/back Sakhalin projects and Alaska. We increased considerably our knowledge about the Arctic conditions. Atomflot, of course, provided us with icebreaker assistance. For instance, in 2014 two icebreakers "Vaygach" and "Yamal" made the ice channel for our vessel. That transit took 16 days for "Tor Viking" eastward to reach the Sakhalin-1 project".

It is worth noting that while "Balder Viking" during several contracts at Prirazlomnaya platform did not need to change the Swedish flag into the Russian, both vessels "Vidar Viking" and "Tor Viking" had to change their flags into the Russian flag[132].

"It was the first and important experience for Viking Supply to operate the vessel under the Russian flag with the Russian crew, using the Russian resources and collaboration with the Russian government", as commented the interviewee of Norwegian shipping company #1 on the participation of both "Vidar Viking" and "Tor Viking" in Sakhalin.

All the other vessels presented in Table #21 did need to change their original flags into the Russian flag because they were involved in both Universitetskaya-1 well and Dolginskoye field projects only for the very short period of drilling operations.

[132] According to the Russian legislation, an international vessel is allowed to operate in the Russian waters under its origin flag only within six months. Then, the vessel has to change its origin flag into the Russian flag (the 1st author's note).

Table 21. ***International OSVs engaged temporally in operations on the Russian Arctic shelf.***

Owner	**Vessel name**	**Flag**	**Built**	**Ice class**	**Type**	**Emergency preparedness equipment**	**Project**
Viking Supply Ships, AS	"Balder Viking"	Sweden	2000	DnV Ice-10, +1A1	AHTS	-	Universitetskaya-1 well in 2014
							Prirazlomnaya in 2013, 2015, 2018
	"Brage Viking"	Norway	2012	DnV-GL, Ice-1A Super, +1A1	AHTS	FiFi II, Oil Rec., NOFO2009; 120-200 evacuees	Universitetskaya-1 well in 2014
	"Loke Viking"	Norway	2010	DnV, Ice-1A; +1A1	AHTS	FiFi II, Oil Rec., NOFO2009; 120-200 evacuees	Universitetskaya-1 well in 2014
	"Magne Viking"	Denmark	2011	DnV, Ice-1A; +1A1	AHTS	FiFi II, Oil Rec., NOFO2009; 120-200 evacuees	Universitetskaya-1 well in 2014
	"Vidar Viking"	Sweden/ Russia	2001	DnV Ice-10; +1A1	AHTS	winterized	Sakhalin-2 in 2012-2014, 2014-2016, 2016
	"Tor Viking"	Sweden/ Russia	2000	DnV Ice-10; +1A1	AHTS	winterized	Sakhalin-1 in 2012- 2014
Siem Offshore Rederi, AS	"SIEM Amethyst"	Norway	2011	DnV, Ice-C, +1A1	AHTS	Oil.rec., NOFO2009, FiFi, De-ice	Universitetskaya-1 well in 2014
	"SIEM Topaz"	Norway	2010	DnV, Ice-C, +1A1	AHTS	Oil.rec., NOFO2009, FiFi 2, De-ice, 300 evacuees	Universitetskaya-1 well in 2014
	"SIEM Pilot"	Norway	2010	DnV, Ice-C, +1A1	Platform supply vessel	Oil.rec., FiFi 2,	Universitetskaya-1 well in 2014
Rem Supply AS	"REM Server"	Norway	2011	DnV, Ice C, +1A1	Platform supply vessel	Oil. Rec.	Universitetskaya-1 well in 2014
	"REM Supporter"	Norway	2012	DnV, Ice-C, +1A1	Platform supply vessel	Oil. Rec.	Universitetskaya-1 well in 2014
Island Offshore Group	"Island Crown"	Bahamas	2013	DnV, Ice-C, +1A1	OSV	Oil. Rec.	Universitetskaya-1 well in 2014
TS Shipping Haren	"Botnica"	Estonia	1998	DNV Ice-10	Multipurpose icebreaker	2 5MW Azipods, Helipad,	Universitetskaya-1 well in 2014
Simon Møkster Rederi AS	"Strilborg"	Norway	1998	DnV +1A1, ICE-C	AHTS	Oil. Rec. NOFO 2009, DYNPOS AUTR., FiFi I&II, 300 evacuees	Dolginskoye field (in 2014)
Stril Offshore AS, c/o Simon Møkster shipping AS	"Stril Challenger"	Norway	2009	100A1, 1E	AHTS	Oil. Rec. NOFO 2005, FiFi I, First-aid assistance, 280 evacuees	
	"Stril Comman-der"	Norway	2009	100A1, 1E	AHTS	Oil. Rec. NOFO 2005, FiFi I, First-aid assistance, 280 evacuees	

In addition, the findings of the report have shown that both Gazprom and Rosneft are used to employ international OSVs for drilling operations on the Russian shelf. For exploitation operations, both companies use the OSVs owned by their subsidiaries and/or other Russian ship owners.

<u>The OSVs engaged in the Russian Arctic and sub-Arctic projects nowadays:</u>

The Russian offshore fleet is generally presented by a variety of OSVs owned and operated by the following companies: Dalmorneftegeophysica (DMNG). Gazflot, FEMCO, Luk'oil, Marine Arctic Geological Expedition, Northern Shipping Company (NSC), Sovcomflot (SCF)[133]. In this report, we specifically focus on OSVs, which operate only in the Arctic areas (See Table #22).

Table 22. ***The Russian market of OSVs that operate in the Arctic areas nowadays.***

Owner	Vessel name	Flag	Built	Ice class	Type	Characteristics	Emergency preparedness equipment	Project
Gazflot - subsidiary of Gazprom	"Yury Topchev"	Russia	2006	DNV Ice-15	Multifunctional icebreaking supply vessel	2 ABB Azipod units; Ice thickness up to 1.7 m, t = down -50^0C	equipment for oil spill recovery	Prirazlom-naya platform
	"Vladislav Strizhov"	Russia	2003	DNV Ice-15	Multifunctional icebreaking supply vessel	Ice 2 ABB Azipod units; thickness up to 1.7 m, t = down -50^0C	equipment for oil spill recovery	
FEMCO	"Aleut"	Russia	2015	Icebrea-ker 6; ARC5	Supply vessel		Oil.Rec., DYNPOS-1, Winterized (-30), FiFi 3	Prirazlom-naya platform
	"Kigoriak"	Russia	1979	Ice class3	Anchor handling vessel		Oil water separator, rescue boat, life rafts for 80 persons, FiFi - Fire pump, emergency fire pump	Sakhalin-1
	"Vengery"*[134]	Russia	1983	1A Super	AHTS	Decommissioned currently		Sakhalin-1 (2005-2006)
Rosmorrechflot - The Federal Agency for Maritime and River Transport	"Murman"	Russia	2015	Icebreaker 6	Rescue vessel	Propulsion: 2 x 3500 kW Azipods	Oil.Rec., DYNPOS-2, FiFi 2, helidec; 95 survivors	Prirazlom-naya platform
	"Spasatel Kavdeykin"*	Russia	2013	Ice-1A*	Multipurpose rescue vessel		DYNPOS-2, Oil.Rec., 2skimmers	Universitets-kaya-1 well (2014)
	"Spasatel Karev"*	Russia	2010	Ice-1A*	Multipurpose rescue vessel		DYNPOS-2, Oil.Rec., 2skimmers	Dolginskoye field (2014)

[133] For more information, see http://offshore-fleet.com/data/companies-russia.htm

[134] In the project, this vessel participated under its former name "Crowley Alliance" that it had until 2007 (the 1st author's note).

Sovcomflot (SCF)	SCF Sakhalin	Russia	2005	DNV Ice-10; RMRS Icebrea-ker 7	Platform supply and stand-by vessel	2 ABB Azipod units, 2 bow thrusters; Ice thickness up to 1.7 m, t = down -500C	winterization, Oil. Rec., oil spill response gear, Arctic oil skimmer, reception tank for oily water, 150 evacuees	Sakhalin-1
	"Vitus Bering"	Russia	2012	DNV Ice-10; +100A1	Multifunctional icebreaker - Platform supply and stand-by vessel	2 ABB Azipod units, 2 bow thrusters; Ice thickness up to 1.7 m, t = down -50^0C	winterization, Oil.Rec.; oil spill response gear, Arctic oil skimmer, FiFi 1; reception tank for oily water, 195 evacuees	Sakhalin-1
	"Aleksey Chirikov"	Russia	2012	DNV Ice-10	Multifunctional icebreaker - Platform supply and stand-by vessel	2 ABB Azipod units, 2 bow thrusters; Ice thickness up to 1.7 m, t = down -500C	winterization, Oil.Rec.; oil spill response gear, Arctic oil skimmer, FiFi 1; reception tank for oily water, 195 evacuees	Sakhalin-1
	SCF Endurance	Russia	2006	Ice-10; +1A1	Icebreaking platform supply vessel		Oil-Rec, 150 evacuees	Sakhalin-2
	SCF Enterprise	Russia	2006	Ice-10; +1A1	Icebreaking platform supply vessel		Oil-Rec, 150 evacuees	Sakhalin-2
	SCF Endeavour	Russia	2006	Ice-10; +1A1	Icebreaking platform supply vessel		Oil-Rec, 150 evacuees	Sakhalin-2
	"Fedor Ushakov"	Russia	2017	Ice-15; +1A1	Multifunctional icebreaking stand-by vessel	Able to operate in 1.7 meter thick ice	Winterized Cold, Dat (-35°C), FiFi 1, Oil Rec., 150 evacuees	Sakhalin-2
	"Gennadiy Nevelskoy"	Russia	2017	Ice-15; +1A1	Multifunctional icebreaking platform supply vessel	Able to operate in 1.7 meter thick ice	Winterized Cold, Dat (-35°C), FiFi 1, Oil Rec., 150 evacuees	Sakhalin-2
	"Stepan Makarov"	Russia	2017	Ice-15; +1A1	Multifunctional icebreaking standby vessel	Able to operate in 1.7 meter thick ice	Winterized Cold, Dat (-35°C), FiFi 1, Oil Rec., 150 evacuees	Sakhalin-2
	"Yevgeny Primakov"	Russia	2017	Ice-15; +1A1	Multifunctional icebreaking standby vessel	Able to operate in 1.7 meter thick ice	Winterized Cold, Dat (-35°C), FiFi 1, Oil Rec., 150 evacuees	Sakhalin-2
Gazprom Neft[135]	"Alexander Sannikov"	Russia	*2018*	Icebrea-ker 8	diesel-electric icebreaker – ice-class tug & rescue vessel	Able to operate in ice of up to 2m thick, the principle of zero emissions	FF1WS, DYNPOS-2, ANTI-ICE, ECO, Oil.Rec. Winterization	For Novoportovskoye field project to ensure the

[135] For more information, see http://www.gazprom-neft.com/press-center/news/1115315/

							(-50°C), hospital, treatment room, isolation cabin, helipad for a Mi-8	year-round operation of the Arctic Gates oil export terminal, located in the western part of the Gulf of Ob, SAR operations, oil spill response
	"Andrei Vilkitskiy"	Russia	*2018*	Icebrea-ker 8	diesel-electric icebreaker – ice-class tug & rescue vessel	Able to operate in ice of up to 2m thick, the principle of zero emissions	FF1WS, DYNPOS-2, ANTI-ICE, ECO, Oil.Rec. Winterization (-50°C), hospital, treatment room, isolation cabin, helipad for A Mi-8	
Rosneft[136]	"Ekaterina the Great"	Russia	*2019*		Multipurpose ice-class supply vessel	Able to operate in 1.5 meter thick ice		For projects in the Northern Seas like the Kara Sea and the Laptev Sea
	"St. Maria"	Russia	*2019*		Multipurpose ice-class supply vessel	Able to operate in 1.5 meter thick ice		
	"Aleksander Nevskiy"	Russia	*2019*		Multipurpose ice-class supply vessel	Able to operate in 1.5 meter thick ice		
	"Vladimir Monomakh"	Russia	*2019*		Multipurpose ice-class supply vessel	Able to operate in 1.5 meter thick ice		

* Some explanation to Table #22:

Indication of the years to some vessels in the last column means that they operated within these projects only in specific years and were no longer involved. The other vessels without years to the projects (in the last column) mean that they have been operating within these projects for a long time and nowadays.

In addition to the vessels represented in each separately examined case, Table #22 also includes five offshore vessels for GazpromNeft and Rosneft, which have still been under the construction. At the same time, Table #22 does not contain OSVs that were built specifically for the Russian Navy's Arctic-going fleet, for instance the ice-class Arctic patrol vessel "Ilya Muromets" (built 2017, Icebreaker6).

It is generally known that the primary function of OSVs is to deliver supplies associated with the operation to the offshore installations. Analyzing the data from Table #22 we can find that OSVs constructed in earlier years had a rather narrow specificity, but covering already a quite wide range of additional functions, such as towing offshore structures, drilling rigs and barges, anchor handling and installation of mooring systems, diving, ROV and some other operations. In recent years, the development of OSVs has made a shift towards more multifunctional vessels than only specialist vessels, as we can find in Table #22.

The main Russian players in the oil and gas field development including – Rosneft, Gazprom, Sakhalin Energy, as well as Russian large shipping companies – Sovcomflot have

[136] For more information, see http://www.oilexp.ru/news/world/arkticheskuyu-neft-prikroyut-flagom-video/133910/

recently ordered the vessels of a new series of vessels at shipyards like "Fedor Ushakov". The new vessel type has been designed for extreme environmental conditions with high icebreaking capability. These vessels are able to operate without the icebreaker escort in 1.7-meter thick drifting ice in temperatures as cold as - 35^{0}C. In addition, it is worth noting that they combine high maneuverability, a powerful propulsion system, environmental friendliness, and a large passenger capacity (during an evacuation, the vessel can hold up to 150 people).

"These state-of-the-art multifunctional icebreaking supply vessels can be utilized in many arctic areas in the future and I see a global need for such Arctic vessel", said the Managing Director of Arctech Helsinki Shipyard, Esko Mustamäki, about vessels "Vitus Bering" and "Aleksey Chirikov"[137]. The construction of these vessels ensures and expands *"companies' participation in field projects on Russia's continental shelf",* according to Sergey Frank, President of Sovcomflot (SOE).

The demand for multipurpose vessels for the field projects on Russia's continental shelf can be explained by two basic distinctive features related to most Russian Arctic offshore fields such as the presence of harsh ice conditions, long distances, and the necessity to create at least some basic onshore facilities for each project before the start. Multipurpose vessels are flexible in not only carrying various type of cargo and providing a number of specialized services as a supplement like anchor handling, rig moves, towing, ROV and others, but also they ensure emergency preparedness to SAR and oil spills. In addition, it is worth emphasizing that new multifunctional OSVs in Russia have been built to be engaged in the development of the concrete projects.

At the same time, personnel transportation remains an important issue for Arctic fields located in extremely remote areas from the shore and supply bases. Today helicopters are preferred, but long distances require new thinking involving ice strengthened maritime vessels and multitask vessels for direct and intermediate transportation, as shown by the case of the Universitetskaya-1 well development in the Kara Sea.

Therefore, as oil and gas companies are looking for new fields to be explored on Russia's continental shelf, where local conditions are harsh and challengeable like the Arctic seas, the demand for multifunctional and multipurpose OSVs, providing with more developed and improved services, considerably increases nowadays. In the Russian offshore operations, we can observe the tendency that oil and gas companies prefer to have a large ship owner's share in the supply chain like Sovcomflot, FEMCO, Gazflot.

According to the interviewee of Russian oil company #2,

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[137] Available on: http://www.setcorp.ru/main/pressrelease.phtml?language=english&news_id=46521

"That occurs because there is a limited number of service providers and too much limited number of the customers – Rosneft and GazpromNeft. Multifunctional OSVs integrate different kinds of equipment on board and provide the whole capacity in this case. They becomes also of importance due to extreme remoteness between the installations and supply bases on the Russian shelf".

In contrast, the Norwegian petroleum companies have still tended to contract OSVs on specific specialty, which provide a wide range of specific functions, because

"there is a large number of customers – more than 50 oil companies in Norway, and a large number of independent suppliers on the Norwegian offshore market", according to the interviewee of Russian oil company #2.

4.3. OSVs' services required in the High Arctic

The demand for OSVs is defined by the harsh and challenging environment in the Arctic with specific requirements on OSVs functions and design.

"While the ship-owner knows how to build and design a vessel, the oil company, which operates in concrete specific conditions, is the only who realizes how to use the vessel and what kind of features it needs" – as told by the interviewee of Norwegian shipping company #1.

In addition, *"the very latest innovations in shipbuilding science and technology are in high demand from both Russian and international oil and gas companies"*, said Sergey Frank, President of OAO Sovcomflot[138]. The following OSVs' services are in demand:

- Cargo supply;
- Anchor handling and towing;
- Ice management;
- Emergency preparedness and standby;
- Special navigation systems on board;
- Special vessel capabilities: ice strengthening and winterization.

We may here find different solutions as to multi-functionality within each ship versus more specialized vessels as listed below:

[138] Available on: http://www.setcorp.ru/main/pressrelease.phtml?language=english&news_id=46521

- **Each ship:**
  - PSVs and AHTVs with maximum multi-functionality due to need for redundancy
  - Highest possible cargo capacity due to distances
  - High maneuverability due to wind, waves and stability issues at rig and a route
  - Helicopter landing platform due to fog and polar lows
  - HIFR-functionality -in-air helicopter fueling facilities
  - High(est) winterization for safety
  - Highest comfort class for crew welfare and stayer ability

- **Fleet:**
  - Redundancy in transport capacity
  - Redundancy in towing for fast removal of rig
  - Ice management capacity against ice berg and ice floes
  - Offshore depot
  - Offshore spare parts and repair facilities
  - Passenger transport and hotel capacity
  - Hospital capacity
  - Helicopter fueling and hub capacity

4.3.1. Cargo supply operational capacity

Almost every Arctic offshore operations are characterized by long distances to ports and onshore supply bases from offshore installations. The cargo type differs very slightly for drilling operations or oil production facilities. The table below illuminates the critical parameters:

LOGISTICS VALUE:
• **Cost efficiency:** Supply chain time efficiency • Cargo damage elimination • Productivity-resource per ton distance • Transaction-cost reductions
Quality and effectiveness: • Prompt delivery • Coordination between service providers • Flexibility • Responsiveness
Safety, security, sustainability and stakeholder relations: • Person and ship safety and security • Capacities within preparedness (SAR, ORO, etc.) • Hub capacities • Public relations capabilities

One of the main challenges is the fuel supply to the rig. Both increased tank capacities and deck space may be needed. This calls for larger vessels than the ones serving today. Using a hotel and storage vessel on site is another solution used both in the Greenland and Kara sea operations.

According to the interviewee of Russian oil company #2, *"If a field's location is too remote, for commercial purposes, an operator can organize a drill tanker in the vicinity of the field site. This solution can be valuable and reasonable only if the tanker is used for servicing more than one site".*

Almost all Arctic offshore field projects are characterized by the extreme remoteness and too long distances between onshore supply bases and offshore installations.

As told by the interviewee of Russian oil company #3, *“The OSV capacity is significant factor for us due to long distances to carry the necessary supplies”*.

The long distances in transport and weather delays may be followed by limited time windows for loading and discharging between the rig and the vessel due to wind and wave conditions. The limited satellite communication may hamper positioning at the rig run by the dynamic positioning system on board. This may call for extra use of satellite capacities for GPS correction signals, extra low-angle GPS antennas, and extra link-up facilities to the rig for exact positioning, for example through the Radius system.

4.3.2. Anchor handling and towing

This service refers to securing the stability of an offshore facility by mooring anchors to the sea bed. Modern drilling units possess a dynamic positioning system when anchor handling is less required. However, in the High Arctic offshore fields with ice constant flowing and the water depth it may require both dynamical position systems and anchor handling.

Towing is mostly referred to exploration activities, when a drilling rig is moved in and out of the drilling site. The towing duty is challenging and has been subject to accidents. For instance, the jack-up rig “GSP Saturn” was damaged in stormy weather by waves in the Pechora Sea in November 06, 2014 when it was towed to Murmansk after the drilling operations at the Dolginskoye field. In the mid-December 2011, the Russian jack-up rig “Kolskaya” with 67 crew onboard capsized and sank within twenty minutes during a storm in the Okhotsk Sea while being towed through a winter storm, leaving more than 50 dead or missing in the icy waters[139].

The water depth can be a problem for both rigs and dynamical positioning systems due to constant offset movements of the drill installation.

As told by the interviewee of Russian oil company #3,

“The water depth at the Dolginskoye field is only about 40m. So, the offset movement of jack-up rig “Saturn” could reach up to 0.8 m. We took additional efforts that anchor handling could secure this maximum of the rig offset movement. At the same time, the water depth was a reason why we used a jack-up rig during the drilling operations in summer months of 2014 because this type of rigs decreases the demand for anchor handling activity, but increases the demand for towing. This specificity added to some extent nervousness to implement and finish all the necessary operations in a short window before the ice came”.

[139] For more information, see https://www.reuters.com/article/us-russia-platform-capsize/russian-rig-sinks-more-than-50-feared-dead-idUSTRE7BH04020111218

4.3.3. Ice management

One of the rules in the book, titled "Handling ships in Ice", says: *"Work with the ice, not against it!"* (Buysse, 2007).

Arctic offshore operations are a very demanding job in extremely difficult conditions. During the winter, many Arctic areas are characterized by the air temperatures down to -35 C°, waves up to 18 meters in height, wind speeds 140 kilometers per hour and the ice thickness up to two meters. It is important that the oil and gas rigs are served by vessels, which are capable of managing masses of ice effectively. In the worst case, piling masses of ice can damage production platforms and cause serious danger to people and the environment. Proactive ice management by using special vessels is therefore a crucial factor.

Table #22, shows that on the Russian continental shelf there is a demand for supply vessels that are able to perform ice management services, ensuring the year-round delivery of supplies without icebreaker assistance with high maneuverability in the Arctic winter. The new Russian offshore vessels like "Vitus Bering", "Aleksey Chirikov", "Gennadiy Nevelskoy", "Fedor Ushakov" have been designed specifically for these tasks. The vessels are based on double acting ship concept and move bow first in open waters, then stern in heavy ice providing icebreaking functions.

With proper ice management, the drilling season can be extended in some areas from a 2-3 months window to all year round, according to the interviewee from the Norwegian shipping company #1.

Ice management includes a number of different tasks like icebreaking, ice monitoring, providing the knowledge hon ow the ice conditions differ and how the ice moves, iceberg towing, deflecting sea ice and ice floes, surveillance, operational ice charts, and ice advisory.

"It's important to choose the right ice-advisors that can find the optimal solution for the concrete project!", as emphasized the interviewee of Norwegian shipping company #1.

Monitoring the ice movements is a constant challenge. For instance, in case of drilling operations at the Universitetskaya-1 well in the Kara Sea in 2014, ice monitoring, including breaking ice formations and altering possible iceberg courses, was carried out by separate vessels not to distract supply vessels from their main functions.

"To make sure the drilling operations was not at risk, we used 5 drones and iceberg tracking to survey the proximity of the protected area during drilling operations in the Kara Sea" – according to the interviewee of Norwegian shipping company #1.

An additional challenge to ice management is underdeveloped monitoring systems and polar night conditions.

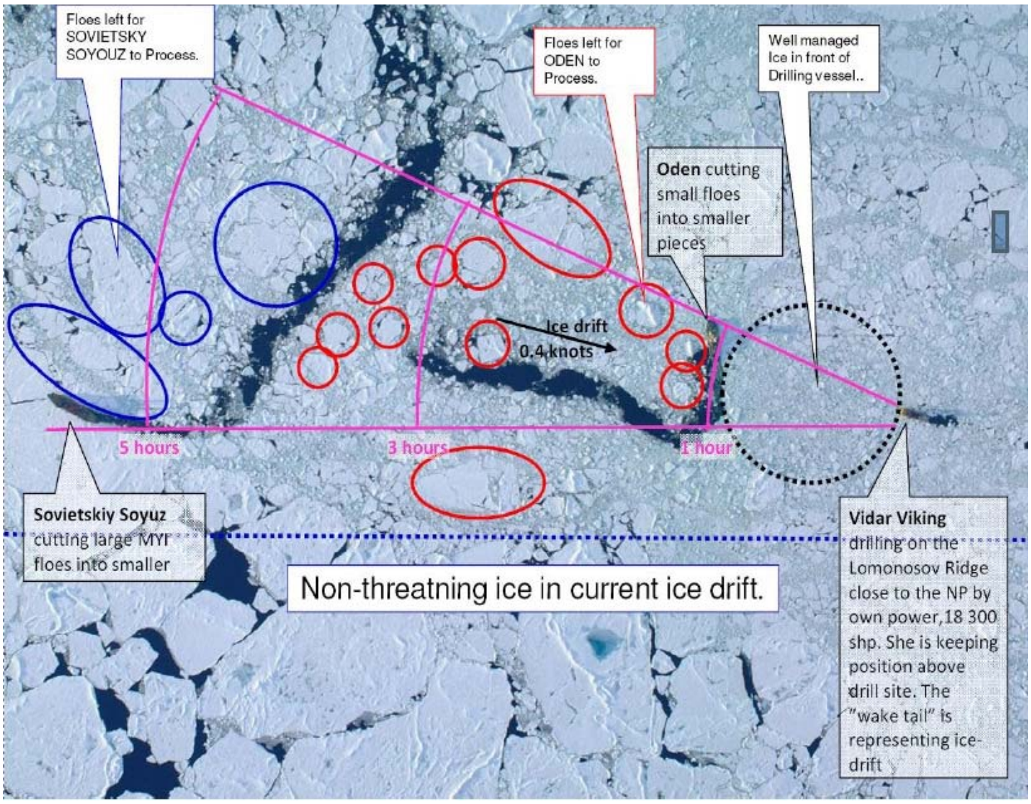

Figure 104. Providing ice management services by "Vidar Viking" on the Lomonosov Ridge close to the North Pole in 2003 (Source: vikingsupply.com)

The company Rosneft has been paying attention to the development of experience and skills in ice management for the past several years, by performing experimental work in the waters of the Kara and Barents seas. Within the Kara Summer-2016 expedition, Rosneft tested for the first time in Russia the technology allowing changing the trajectory of iceberg drifts by external influence. Icebreaker "Captain Dranitsin" performed 18 successful towages of icebergs in the Kara Sea with a 90 and 180-degree turn of movement vs. their original trajectory. At the same time, specialists managed to successfully perform simultaneous towing of two icebergs. Within the Kara Summer-2017 expedition, Rosneft and specialists of the LLC Arctic Science Center performed eight experiments detecting and tracking of icebergs using different technical tools, including drones. In addition, 18 experiments on physical impact on icebergs were successfully performed, including the use of towing equipment, propellers and water cannon. During the Kara Summer-2017, the maximum weight of the towed iceberg was 1.1 million tons; the towing of the iceberg per day was 50 miles (from the southern part of the British Channel to the Geographer's Bay of Prince George Land Island located in Franz Josef Land); the maximum towing speed was 3.2 knots (about 6 km/h); maximum wind speed at towing -15m/s[140].

[140] For more information, see https://www.rosneft.ru/press/news/item/188167/

"The experiments performed during the Kara Summer expeditions will allow to protect the marine infrastructure from contact with icebergs while performing operations in the Arctic seas, particularly in the Kara Sea, Laptev Sea and Chukchi Sea" as emphasized by the interviewee of Russian oil company #2.

Figure 105. Kara Summer-2017 expedition (Source: Rosneft.ru)

The Kara Summer-2017 expedition also aimed to develop training scenarios on the interaction of the icebreaker and the Coast Operations Center in protecting the conventional offshore oil and gas production facility from the iceberg threat in the Barents and Kara Seas. Each of the scenarios determined the location of the "platform" in an area with a large number of icebergs, the degree of ice danger for the protected object, and the drift of dangerous ice formations was monitored.

4.3.4. Emergency preparedness and standby functionality

Due to long distances from the shore and supply bases and logistics challenges linked to low temperatures and poor daylight conditions, emergency preparedness and oil response capability become a special and even rather essential functions for the development of oil and gas projects in Arctic waters.

As told by the interviewee of Norwegian shipping company #1:

"The offshore installations have to be fully self-sufficient due to the remoteness, because it will take a much long time for the nearest assistance to reach the installation in case of any emergency or accident. OSVs are the only ones that are able to ensure this capacity in the Arctic waters. We face a number of issues with the use of helicopters. For example, the inability to use

helicopters because of the abundance of fogs or the presence of military bases like in the Kara Sea. These issues increase the risk and affect the cargo capacity of OSVs negatively".

"That's why all operations in Arctic waters require too long and careful preparations before they start in real conditions" as added by the interviewee of Norwegian oil company #1.

In most field projects, OSVs are equipped with the necessary equipment to be ready for participating in developed emergency plans in case of a failure. However, this may not be sufficient at all when you are dealing with ice as emphasized by the interviewee of Norwegian shipping company #1:

"When oil companies operate in the ice, emergency prevention and oil spill response capabilities decrease considerably. There is actually no good solution today how to treat an oil spill in ice. You can probably burn it off?!? But there are no vessels and sufficient equipment for today, which are able to collect oil from the ice and/or ice mixed with oil. I think what we can do is to take the best equipment, the best people we have and do our best out of it. We have to not allow anything go wrong in Arctic icy waters".

Ice management is ensuring emergency preparedness according to the interviewee of Norwegian shipping company #1:

"The operators and all others involved in the field project should be aware of where the ice is and where the ice is moving. Using OSVs with high ice class and towing equipment, you can tow away the ice, maybe with oil, from the platform and then you can tow it to the area where you can start collecting oil. So, good skills in ice management are important for emergency preparedness along with good equipment and well-trained personnel".

The findings of the report have also shown that one of the most important capacities of OSVs is the ability to accommodate 100-200 persons on board in case of an emergency evacuation from the rig (see Tables #20,#21,#22).

"It is a real challenge to perform the evacuation operation in high waves and drifting ice" as told by the interviewee of Norwegian shipping company #1.

"The number of standby vessels can depend on the distance to shore and reach 2-3 vessels near one platform. For instance, in Equinor, we have a general requirement that the first recovery system should be in the sea within five hours. However, at the Korpfjell, according to NOFO arrangement, the whole recovery system should be in the sea within two hours to start the emergency operations", according to the interviewee of Norwegian oil company #1.

4.3.5. Ice surveillance tools

In order to obtain safe and effective operations in the demanding Arctic waters, there is a strong necessary to use special navigation systems on board and operational systems by sharing information between all project participants.

"Be aware of challenges! – We follow this principle as decisive that everyone in the project sees the same operational picture in real-time getting the same information and messages integrated in a single system for both offshore and onshore units. We call our system "COPD - Common Operational Picture Display". It makes everybody in the project – people on the rig, from oil companies, crews on board, suppliers, vessel operators - be aware of the situation: time data, the weather and ice conditions, the position of the vessels, and so on", as told by the interviewee of Norwegian shipping company #1.

The combination of both integrated navigation systems and geographical information systems can provide with effective logistics solutions, particularly when all operations have to be carried out for very short operating window before the ice season begins again.

"When everybody see the same picture how the ice is moving, you can plan the operations much more efficient, because you can predict where a new open window is during next several hours. You don't need to explain, argue or discuss your next strategic steps with anybody. Everybody has the same picture that makes it clear how the best safe operations can be carried out", as commented by the interviewee of Norwegian shipping company #1.

4.3.6. Ice strengthening and winterization

One of the main features for the vessels to operate in Arctic waters and meet cold-climate operating needs are:

- Ice strengthening – via the PC polar ice classes, from PC(1) to PC(7), and the Baltic ice classes, ICE(1A*) to ICE(1C);

- Winterization – the protection of ship systems from freezing and avoiding ice on superstructure.

The following experience with respect to ice strengthening capability was shared by the interviewee of Norwegian shipping company #1:

"We had a vessel with ice class 1A. We assumed that if we could modify the vessel design and increase the ice class, we were able to qualify that vessel for some other jobs. So, we

redesigned the vessel to 1A Super (1A+). And that was something what was appreciated by Exxon Neftegaz (operator of the Sakhalin-1 project) and they decided to employ our vessel instead of another. I mean if we would not make a decision about the modification of the vessel, we could not be qualified for being involved in the operations in Sakhalin".

The preparation of equipment for extremely low winter temperatures reduces stress levels, cuts downtime and ensure the safety of personnel.

"Equipment on board designed for use in particularly extreme cold conditions is of great importance to prevent damage, reduce stress and cut downtimes. As we can say here: "Pay me now or pay me much more later". I mean that without due attention to the winterized requirements, the operational efficiency of a vessel can be at high risk in cold-climate conditions", according the interviewee of Norwegian shipping company #1.

Temperature maintenance anti-icing and de-icing systems on OSVs will prevent ice formation on exposed surfaces that can create serious problems, influencing the safety of personnel and operations on board OSVs, platforms, walkways and helidecks.

The findings, based on Table #22, have also shown that the icebreaker capability inherent in vessels specially designed to break ice is in demand for the Russian Arctic and sub-Arctic field projects.

4.3.7. Additional vessel equipment

Additional demands for operations will be added spare parts stores both onboard and on the supply base as there may be more strain on technical equipment and more difficult transport to get spare parts on short notice.

This also includes equipment and capacity in the hospital on board the vessels, where more advanced medical equipment may be needed as transport to hospital may be take time.

For the crew, lack of communication to shore and more time in the sea may call for more entertainment facilities to avoid fatigue and depressions.

4.3.8. Innovation in OSV vessels towards the Extreme Arctic

There has been a continuous development in vessel technology including increased functionality. Most vessels built in the Norwegian sector have a low ice class (Ice C). The vessels are built larger with more deck cargo tank load capacity, more advanced navigation and positioning technology. Especially platform supply vessels have had increased functionality as to search and rescue and oil spill response.

Troms Arcturus. PSV
Type: PSV, VARD CD 07, Built: 2014 Aukra.
Class: DNV 1A1 ICE-C DYNPOS-AUTR, Clean Design, Comf-V(2)-C(3), E0, LFL*, SF, Oil rec, DK+HL 2,8 NAUT-OSV(A), Winterized Basic, NMD Rescue (150) NOFO 2009,
Gross tonnage: 4969 t, Length overall 94,65 m, Deck area: 1150m2

Figure The platform supply vessel Troms Arcturus. http://www.tromsoffshore.no

The Vard design CD 07 as shown in the picture above is an example of the continuous development in capacities and functionality, with ice class, an enhanced comfort class, MD rescue and NOFO oil response classes as well as winterization that makes it well suited for operations in the Southern parts of the Barents Sea.

The table below shows how the vessels for the colder, icier, and more remote oil and gas regions may be configured.

	Low Arctic (no sea ice)	Medium Arctic (risk of ice)	High Arctic (1^{st} year ice)	Extreme Arctic (multi-year ice, ice bergs)
Class:				
PSV/ERRV	Ice1C	High Ice1A*	PC 5	PC5
AHTV	Ice 1C	1st year ice	PC5	PC4
Winterization	Basic	Cold	Polar	Polar
Comfort class	High (2)	Highest (1)	Highest (1)	Highest (1+)
Emission/sea noise	Battery-LNG	Battery-LNG	Battery-LNG	Battery-LNG, diesel
TRANSPORT				
Cargo capacity	1100m2	1200m2	1400m2	Xlarge 1500m2
Hotel capacity	25-50	25-50	50+	75+
PREPAREDNESS:				
Rescue capacity	NMD 150	NMD 150	Advanced SAR equipment and hospital	Advanced SAR equipment and hospital
Oil Recovery ORO	Medium	High	Advanced	Advanced
Surveillance	Low	High	Very high	Very high
Fire-fighting	Fi-fi 1	Fi-fi 2	Fi-fi 3	Fi-fi 3

The table above illuminate the extra vessel demands when we move from low Arctic to the extreme Arctic. In the Low Arctic the challenges is not sea ice but a harsh winter climate with icing and heavy winter storms, and heavy fog in summer time, like in the Barents Sea South. In the High Arctic the challenges are multitude with heavy icing risk, ice bergs and multi-year ice, as in the eastern part of Russia.

The vessel characteristics has to be developed towards a higher ice class with strengthened hull and engine capacity, moving way up the scale towards ice breaker classes. This will, however, both increase the investment costs and the operating costs as well, and increase emissions. Thus, the ship owner may need assurance for an all-year and a longer term contract than normal. The winterization and increase in comfort class are also costly. The reduction in emissions and sea noise is obligatory and the demands to use the lowest emission fueling achievable will continuously increase. Moving to battery and LNG-gas powered engines may cause a reduction in tank cargo capacity due to space demands for LNG-fuel and batteries. Battery charging and LNG fueling facilities must also be available at bases.

Increases in cargo capacity and passenger call for an increase the length and breadth of the vessel. A longer vessel may operate with higher speed. However, it may reduce the maneuverability in situations with high waves and strong wind in loading and discharging positioning along the rig calling for more thruster capacity.

The functionality as to emergency response should be at the highest capacity and state of the art. The special needs in this field calls for innovations beyond the present notations when it comes to equipment that can operate at very low temperatures and in icy conditions. As an example, innovation areas within emergency, search and rescue could be:

- Situational awareness tools, vessel sensors, surveillance, UAV,
- Remote maneuvering, route transfer
- Escape tools facilitating evacuation from other vessels and installations
- Broadband radio and mobile communication uplinks
- Polar adapted personal rescue equipment – rescue suits, personal sensors, immersion suits
- Evacuation tools (winterized rig gangways, MOB boats, life boats, life rafts, ice floe tents and equipment)
- Helicopter adaptation for lifting and transfer persons and collective rescue units
- Telemedicine

These special demands within evacuation, search and rescue opens for opportunities for a PSV having this capacity to serve at least periodically as stand-by guard, emergency response and rescue vessel (ERRV) for a region or linked to a specific rig/installation.

As discussed above, there are pro and cons as to an increased number of functions built in one vessel. Therefore, there is a need for a discussion on multi-functionality turning towards a "multi-useless" reputation with lower operational capacity. Some tasks may therefore be channeled to more specialized vessels more tailor-made for the Arctic region.

As an example, passenger transport and SAR-capacities may be built into one specialized type of vessel. The points below shows how such a vessel could be configured.

- Large passenger capacity 100-150 pax
- Fast going: 15-25 knots
- Very high stability -limited heave and roll
- Very high positioning capability-reference systems
- Very high winterization
- Highest comfort class
- Hospital with treatment ward and observation rooms
- Mobile broadband systems
- Heli platform
- Drone capacity
- Heave-stabilized rig gangway solutions
- Heave-stabilized crane for personnel lifting
- Environment-friendly – low emissions – Hybrid LNG-electricity engines

Table. Functionality criteria Passenger transport and evacuation vessel

The demands shown above opens for a more specialized construction with high speed as well as high stability and maneuverability at rig. In general, the innovation process has to take a broad view in the High Arctic region, with more actors involved to achieve more radical innovations. Close cooperation on new design demands and experience sharing as to present technology between the oil companies, ship owners and design companies are strongly recommended.

4.4. Supply bases

An onshore supply base is a complex of operational and maintenance services to support wells and further extraction of oil and gas on the continental shelf. Onshore supply bases may accept, handle, store different cargos, materials and equipment, as well as provide domestic and industrial waste treatment services, including drill cuttings.

According to the data from the interviews with several respondents, we can generally identify the following challenges of onshore logistics:

- Planning and execution of inbound logistics, loading and unloading,
- Long distances to the offshore installations;
- Dependence on contractors.

Servicing the activities in the Norwegian Barents Sea:

Two supply bases organized by NorSeaGroup (Polarbase) and ASCO Company serve the petroleum activity on the NCS in the Barents Sea (see Table #23). Both supply bases are located in Hammerfest, which is the nearest port at the shortest distance to the field projects. This location makes both supply bases important participants for the ongoing and future development of field projects in the Norwegian Barents Sea.

The Polarbase, built on a concept "A one stop shop", has been the supply base for operators engaged in exploration and production drilling in the Barents Sea since 1980[141]. ASCO Hammerfest Base was established in January 2016 after being awarded a contract with OMV (Wisting project) and has handled all supply base services for Lundin Norway related to the activities in the North Sea since 2013[142].

[141] For more information, see http://ziggi.no/en/portfolio/video-polarbase-basen-for-barentshavet/
[142] For more information, see http://ziggi.no/en/portfolio/video-asco-base-hammerfest/

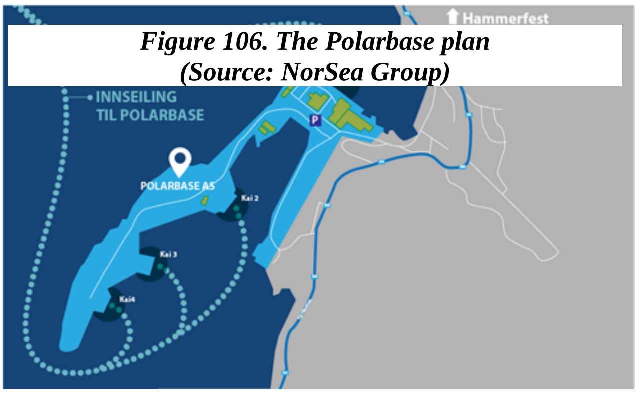

Figure 106. The Polarbase plan (Source: NorSea Group)

Figure 107. The Polarbase in Hammerfest (Source: iFinmark.no)

Figure 108. ASCO Hammerfest base (Source: ASCO)

Both bases provide integrated logistics services when oil/gas companies can operate along the entire Norwegian continental shelf under one contract.

Land transport between supply bases and to/from the supply bases in Hammerfest is carried out by trucks of freight-transport company “Bring Logistics” and by ships of “Norlines”. For instance, in 2012, Equinor shipped approximately 110 000 tons base-base in Norway only by trucks. In 2017 from January-July there were shipped 2.100 tons using boat to/from Hammerfest & Sandnessjøen with “Norlines” (from the interview with the representative of Equinor).

The Norwegian government requires that the base location has to be as close as possible to the offshore field projects. Secondly, the supplier industry, including deliveries to the petroleum sector, transport and communication, office-related goods and services at oil companies have significant ripple effects on the regional development like Northern Norway and particularly Finnmark. In 2013, the turnover related to deliveries to the petroleum development in the Barents Sea was 1,407.20 MNOK as the greatest volume among other northern municipalities. This is mostly due to the opening of ENI's new office in Hammerfest and Equinor's plant in Melkøya. The governmental strategy is that competence should come from the local community or be moved to the Hammerfest region. Since 2002, when Equinor established its Snøvit project the population in this area has grown with 14 %. Since 2008, when ENI started the Goliat project, the population has grown by 9.35 % (Nyvold et al., 2013). Hammerfest as a location of two northern supply bases has become a strategic gateway to the Barents Sea.

For servicing the activities in the Russian Arctic and sub-Arctic waters:

Offshore fields in the Russian Arctic are far from the infrastructure centers. Hence, there is a challenge to ensure regular supply with necessary materials, equipment, resources. Both Gazprom and Rosneft chose the port of Murmansk as the ground for onshore supply bases (see Table #23). Murmansk port is the largest ice-free ports in Russian Arctic and has a well-developed infrastructure, including transport connection with other regions.

According to the interviewee of Russian oil company #3 (the Dolginskoye field project), *"We have chosen to develop the supply base for the Pechora Sea project at two berths in the Murmansk Sea Fishing Port. Ice-free port of Murmansk, which is located about 1,000 km from the field but linked with the other regions of Russia. We chose it because no transportation hubs are located close to the field"* (for more information see Section #3.2.3. of the report).

According to two interviewees of Russian oil company #2 and Norwegian shipping company #1, *"Rosneft plans to construct a supply base in the vicinity of Murmansk port (in Lavna district), at the territory of 82nd ship repair plant"*.

One of the most important issues at the port of Murmansk is that there is "*insufficient capacity of the railway towards Murmansk, which can become a 'bottleneck' of the supply logistics as the remote approached to Murmansk are busy with delivering fuel to the region"* as noted by the interviewee of Russian oil company #3.

At the same time, onshore supply bases for both Sakhalin-1 and Sakhalin-2 are organized at the ports in the vicinity from the offshore field operations. It is worth noting that today all supply bases located on Sakhalin island start providing services for all Sakhalin shelf projects, based on integrated mechanism -Sakhalin-1, Sakhalin-2; Sakhalin-3; Sakhalin-5; new projects on Far East shelf and on Sakhalin.

Table 23. *Overview of the onshore supply bases*

Field project	Main onshore facility	Distance: offshore units - onshore facilities	Respon-sible	Main challenges & peculiarities of the main facilities	Additional facilities	Respon-sible
The Norwegian Arctic continental shelf:						
Goliat	Polarbase, inbound transport of all supplies to the base and waste from the base by "Bring-Logistics" trucks	88 km	NorSea Group	- Loading/unloading: it can require too much time up to 20 hours than it actually needs; - Short opening hours of the supply base; - Long demurrage	2 depots in Hasvik (1163 m^2) and Måsøy (1337 m^2) for oil spill protection equipment and oil clean-up exercises	NOFO
					Hammerfest helicopter base	Bristow
					Offices in Hammerfest and Stavanger to facilitate efficient interaction in case of emergencies	Eni Norge
Johan Castberg	Polarbase	240 km	NorSea Group	ASCO base is a supplementary resource. Both bases can relieve each other during periods of high activity	Hammerfest helicopter base to use 2 helicopters	Bristow
	ASCO Hammerfest base		ASCO Norge			
Korpfjell	Polarbase	415 km	NorSea Group	- Loading/unloading: it can require much time, up to 20 hours - Short opening hours of the supply base; - Long demurrage	Hammerfest helicopter base to use 2 helicopters	Bristow
					Extra receiving center in Kirkenes	Equinor
Wisting	ASCO Hammerfest base	314 km	ASCO Norge			

The Russian Arctic continental shelf:						
Prirazlomnaya	Base located on the Kola Bay coast near Murmansk port – supplies come by trucks, trains, ships	980 km (60km to the shore)	Gazprom Neft-Snabzhe-nie	- Several distant bases Leased from 3rd parties; - Remoteness; - Internal transport of supplies by trains/trucks to the Murmansk port; - Lack of subcontractors and no competition among suppliers; - Insufficient capacity of the railway	Transport terminal in the Kola Bay for oil storage, customs clearance, border control, loading onto end-user tankers	Gazprom Neft-Snabzhe-nie
					Varandey airport (1,7 km from the platform) for personnel transportation	Lukoil company
Universitet-skaya well-1	Murmansk operations base at the port of Murmansk	1,600 km	Sakhalin-Shelf-Service, LLC	- Long distance; - Leased from the 3d parties	A permanent Arctic base of rescue personnel and divers in Amderma, a village on the Kara Sea coast	Karmor-neftegas
Fedynsky field	Possible base locations in Murmansk, Kirkenes		No operations yet, drilling operations planned in 2018			
Dolginskoye field	Murmansk port	960 km	Gazprom Neft-Snabzhe-nie	the same challenges like for Prirazlomnaya platform	Varandey airport for personnel transportation	Lukoil company
	Arkhangelsk port (for future operations)	780 km				
Tsentralno-Olginskaya-1 well	Arkhangelsk port	3,600km	Rosneft	- Northern Sea Route; - Dependence on the development and rules of the Northern Sea Route; - Extremely remote location/distance; - Extremely harsh natural conditions; - Seasonality of supplies. Transportation during short summer	Khatanga settlement as the nearest – 350 km	
Sakhalin-1	Korsakov marine trade port	In the vicinity	Sakhalin-Shelf-Service, LLC	Onshore support of Chaivo and Odoptu OPF; onshore drilling facility “Yastreb”; “Orlan” drilling platform	- Kholmsk marine trade port; - Yuzhno-Sakhalinsk Operations Base - Nogliki Supply Base (diesel fuel); - Wakkanai Japanese winter port for rig	Sakhalin-Shelf-Service, LLC
Sakhalin-2	Kholmsk marine trade port	In the vicinity	Sakhalin-Shelf-Service, LLC	All year round onshore support of “Molikpaq” platform and all oil production complex “Vityaz”	- Yuzhno-Sakhalinsk Operations Base; - Nogliki Supply Base (diesel fuel); - Wakkanai Japanese winter port	Sakhalin-Shelf-Service, LLC

4.5. Opportunities for joint offshore logistics operations and cooperation

In Norway integrated offshore logistics services are at hand for several fields close to each other. The development of Arctic Russian offshore logistics has recently started to turn into a strategic integrated process. The findings have revealed several examples in the Barents Sea and Northwest Russia. More opportunities are available in the fields on the border between Norway and Russia, where cross border cooperation is at hand.

4.5.1. Potentials for cooperation in the Norwegian Barents Sea

In the Norwegian Barents Sea, the Norwegian oil companies like Equinor, Eni Norge, Engie (GDF Suez), Lundin and OMV started a collaboration process by establishing Barents Sea Exploration Collaboration (BaSEC) project in April 2015. It is worth noting that the Norwegian government, represented by the Norwegian Petroleum Safety Authority (PSA), has supported the business initiative and emphasized operator collaboration as a key to success for the further field development on the NCS. Since summer 2015, all operators on the Norwegian Continental Shelf were invited to join the collaboration, and now includes 18 operating companies.

"Through the BASEC project, we look into these Arctic remote areas as one industry: is it good for all operators? Is there a common understanding of facing the challenges for the operational activity?" – explains the interviewee of Norwegian oil company #1 and adds *"It requires many years to find new collaborative solutions for future development"*.

Equinor plays an active role in promoting the idea of cooperation between oil companies on the Norwegian shelf and, particularly, in the Norwegian Barents Sea. In 2015, Equinor opened their new logistics and emergency operations center at Sandsli in Bergen in order to find competitive and innovative logistics solutions through increased predictability and improved interaction[143].

Figure 109. The logistics and emergency operations center (Source: Equinor.com)

[143] For more information, see http://www.vissim.no/news/Equinor-s-new-operations-center-in-bergen-norway

This logistics center is responsible for exercising cost-effective operations of logistics and emergency-response resources, including conducting 24/7 operational resource coordination and optimization of the vessel or helicopter operations. It coordinates the following resources:

1) Vessels and supply: to achieve efficient use of the vessel resources, vessel allocation, optimizing sailing;
2) Air: weather observations, coordination of all helicopter traffic offshore
3) Surveillance and emergency

In 2017, Equinor signed an agreement with Eni Norge for sharing one SAR helicopter and one transport helicopter, which can be converted to a SAR helicopter when needed. Both are Sikorsky S-92 helicopters. This is the cooperation with helicopter operator Bristow and the operating company Eni in Hammerfest.

"The cooperation with Eni on helicopter services in Hammerfest will provide a robust and flexible solution for both the operating companies and the service provider," says Pål Eitrheim, Chief Procurement Officer at Equinor ASA.

This kind of joint procurement of helicopter services in the Barents Sea contributes to flexibility and good utilization of capacity, as well as long-term planning for the supplier[144].

Another example of operator cooperation took place this summer during the drilling operations at the Korpfjell field in 2017. Equinor initiated a cooperation agreement with ENI Norge (Goliat project) and Lundin (Gohta, Alta projects) for extra vessel capacity in order to use "Esvagt Aurora" vessel in the case of emergencies like oil spills.

"This agreement was innovative and the first case where oil companies chose to combine their efforts towards sharing resources. The main idea was to get an access to other operators' vessel capacity. It means a lot of cost savings, including transaction costs, when having cooperation instead of a practice when each operator uses many vessels and helicopters on the project", according to the interviewee of Norwegian oil company #1 [145].

These first steps to develop cooperation between the operators have turned out to be quite positive and, thereby, motivate the Norwegian oil companies to find a mutual solution for sharing OSVs as well.

"When the drilling operations at the Johan Castberg field finish, we would like to elaborate a new agreement with ENI Norge on sharing OSVs from the Goliat project. It could be possible to

[144] For more information, see https://www.Equinor.com/en/news/18sep-hammerfest.html
[145] The services of a transport helicopter for the crew shift cost about 80-90 million NOK per year. To hire a supply vessel on the spot market costs about 200 thousand NOK per day (from the interview).

do this in the future by 2020-2022 when the results of the drilling operations are accepted" – as noted by the interviewee of Norwegian oil company #1 .

Thus, it has given a start towards the concept of common understanding among the operators in the Norwegian Barents Sea *"that cooperation is beneficial for everyone",* according to the interviewee of Norwegian oil company #1.

In addition, Equinor signed a new agreement with ASCO for the next four years of operations since 2017. As noted by the interviewee of Norwegian oil company #1:

"We are looking for new solutions for cooperation in sharing supply vessels if it is possible to use them together somehow. We believe that contracting with both Polarbase and ASCO will contribute to this process. It is because of costs and lack of supply vessels of Arctic class. To hire a supply vessel in the spot market costs about 200 thousand NOK per day."

There is a specific cooperation between NOFO, the petroleum and fishing industries since 2016. Being a coordinating tool to ensure oil recovery preparedness, NOFO started to use fishing boats for emergency response along the coast at the Goliat project. The main task of fishing boats is to tow oil booms that collects, records and stores oil. Now it is assumed to use 27 fishing boats according to the Annual report of 2016[146].

According to the interviewee of Norwegian oil company #1:

"The NOFO's cooperation with the shoreline preparedness fleet turned out to be efficient and profitable to use the fishing fleet, because fishing boats are small. It makes the oil recovery preparedness more effective and adapted to local conditions. The agreements with local fishing boat owners became an important contribution to realizing this goal. Fishing vessels are now used along the entire Norwegian coast. It's good cooperation between the petroleum and fishing industries".

4.5.2. Potentials for cooperation along the delineation line between Norway and Russia

Another important offshore logistics' development area is the delineation line between Norway and Russia in the Barents Sea. As a result of the 23rd licensing round on May 18, 2016, three production licenses have been awarded in the southeastern Barents Sea. Thereby, Norway

[146] For more information, see http://www.nofo.no/globalassets/en_pdfs/annual-report/annual_report_2016_eng.pdf

has opened Arctic oil exploration close to the Russian border[147]. The area along the Norwegian-Russian maritime border represent and arena for potential cooperation between Norwegian and Russian stakeholders in the Barents Sea.

[147] It was possible after the treaty with Russia on maritime delimitation and collaboration in the Barents Sea and the Arctic Ocean came into force on 7 July 2011.
For more information, see http://www.npd.no/en/news/News/2016/Thirteen-companies-are-offered-ten-production-licences-in-the-23rd-licensing-round/

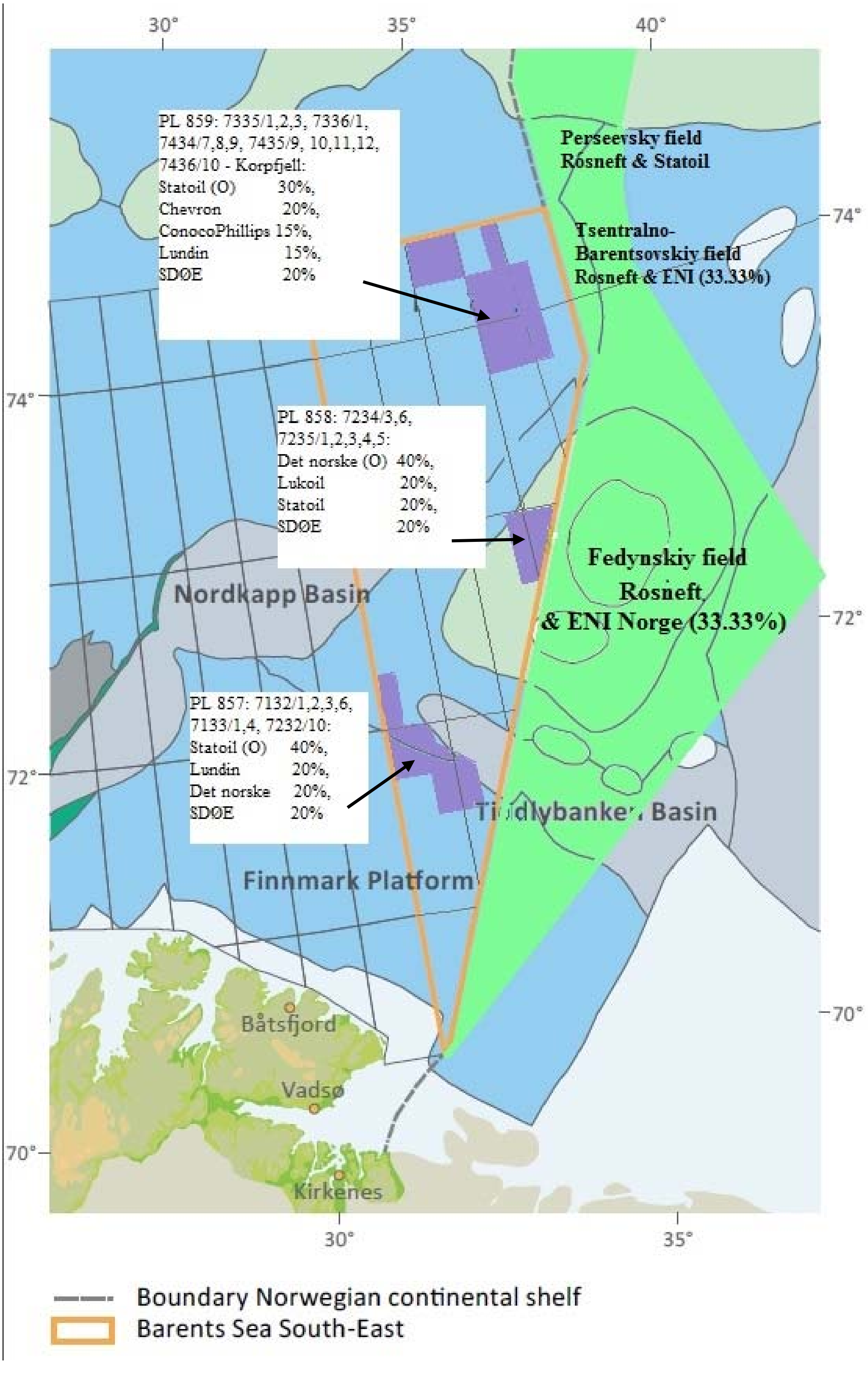

Figure 110. The Barents Sea South-East area along the delineation line
(Source: by the 1st author based on the data of Norwegian Petroleum Directorate and Rosneft.com).

Figure 110 illustrates the fields along the border and groups of companies. The Korpfjell field is located about 20 km from the delineation line and the Perseevsky field, about 200 km from Stockman field. License PL 858 is located from the Fedynskiy field less than 50 km. While Rosneft is operating company on the Russian part of the Barents Sea (in cooperation with Eni and possibly with Equinor), there is a number of license blocks on the Norwegian part and each of them is represented by certain group of companies. Therefore, it is unclear who will be counterparts from the both sides of the operating area in case of cross-border field exploration and further production.

"The success of this area depends on, first, the ability of the authorities and, secondly, the major companies and also the local communities' ability to build a framework for cross-border cooperation!", as noted by the interviewee of Russian oil company #2.

The Norwegian Barents Sea South-East is recognized by most of operating companies as a separate area, because it is more or less disconnected from the rest of the Norwegian continental shelf, at least at present.

According to the interviewee of Russian oil company #2, logistics challenges, emergency preparedness, cost effectiveness and cooperation can be viewed as a Norwegian-Russian issue. Dealing with the delineation line, there is a huge number of unresolved issues and questions including:

- the use of helicopters across the border
- how to organize cooperative refueling possibility for OSVs from the Norwegian and Russian sides?
- What requirements have to be arranged for the use of joint resources across the border in the delineation line area?
  - How will the management of an emergency on both sides (of Norway and Russia) be structured and organized?
  - The customs on both sides

"If you take a certain cargo from the Russian supply base in Murmansk in order to deliver it into the Norwegian field, how will you deal with the customs? Different regulations and tax regimes considerably challenge the possibility of cooperation.

The Arctic Council guidelines say that each country is responsible for emergency response management in their waters. However, it stops working when we cross the delineation line situation. Onshore and offshore operations in Norway and Russia are completely different "animals". And now nobody can come with the answer- what needs to put in place?", as argued by the interviewee of Russian oil company #2.

Despite a huge number of challenges, in 2012 Rosneft and Equinor signed the cooperation agreement to jointly explore the Perseevsky license in the Russian part of the Central Barents Sea, which is located at a distance of 20-50 km from the Korpfjell field, where Equinor is the operator[148]. This agreement may trigger further cooperation and joint exploration of fields simultaneously from both the Norwegian and Russian sides along the delineation line[149]. In 2012, Rosneft and Equinor also announced intentions to place orders with Russian shipyards for the construction of ice-class vessels and drilling platforms.

In 2012, Rosneft and ENI Norge also signed a strategic cooperation agreement to jointly explore the Fedynsky and Tsentralno-Barentsovskiy fields in the Barents Sea. The Fedynsky block covers an area of 38,000 square kilometers in the ice-free southern part of the Barents Sea. Sea depth at the block varies from 200 to 320 meters. 2D seismic uncovered 9 promising formations holding total recoverable hydrocarbon resources of 18.7 billion barrels of oil equivalent. In 2018, Rosneft plans to start drilling operations at Fedynsky field. At the same time, there is a certain interest by the government. During his visit to Franz Josef Land at the end of March 2016, President Putin specifically mentioned the Fedynsky license in connection with development plans in the Barents Sea[150].

The Tsentralno-Barentsovskiy block adjoins Fedynsky to the north (See Figure 110). Sea depth here varies from 160 to 300 meters. Earlier seismic work at the block identified 3 promising formations holding total recoverable hydrocarbon resources of more than 7 billion barrels of oil equivalent. First exploration well is to be drilled by 2021, and if successful, second exploration well is to be drilled by 2026[151].

Rosneft will hold 66.67% and Eni will hold 33.33% in the joint project. According to the agreement terms, Eni will finance comprehensive geological exploration work to confirm the commercial value of the fields.

The Barents Sea looks like the most attractive for potential cooperation, resource sharing and field project developments across the Norway-Russia border.

"The more we manage to organize cooperation in this area, the more cost effectively we can organize the development of oil/gas field operations, including logistics. This offshore area is the best to combine low risk and high profit. For instance, one of the reasons for this in the Norwegian part is a favorable tax regime", according to the interviewee of the Russian oil company #2.

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[148] Under the terms of this agreement, both companies agreed also about joint exploration of three licences - the Kashevarovsky, Lisyansky and Magadan-1 – north of Sakhalin Island in the Sea of Okhotsk (the 1st author's note).
[149] For more information, see https://www.Equinor.com/en/news/archive/2012/05/05/EquinorRosneftMay2012.html
[150] Available at: https://thebarentsobserver.com/en/industry-and-energy/2017/04/russian-drilling-barents-sea-coming
[151] For more information, see https://www.rosneft.com/press/releases/item/114471/

This study has showed that cooperation between companies across the Norwegian and Russian borders are in demand. However, there can be observed just a few cases of cooperation among the key players for development integrated logistics operations (see, Table #24). The findings have revealed that the operators have recognized benefits by implementing strategic integrated logistics cooperation. This shows a positive drive towards specific terms and the development and implementation of new practices of logistics operations.

Cooperation across borders may start with the seismic vessel mapping of resources. Norway and Russia have agreed on so-called unitization in the *"Treaty between the Kingdom of Norway and the Russian Federation concerning Maritime Delimitation and Cooperation in the Barents Sea and the Arctic Ocean"*. The oil companies owning licenses on each side of the delineation line has to make a unitization agreement that has to be sanctioned by each country. In the autumn of 2018, Norway and Russia signed an agreement where seismic vessels may pass the borders with 5 km when shooting seismic.

Table 24. ***Potentials for the development of integrated offshore logistics operations in the Arctic areas***

Main initiators	Interests of main players	Actions of cooperation	Field projects
Cooperation in the Norwegian Barents Sea:			
Equinor	Increasing predictability, Monitoring and optimization of vessels and helicopters operations, Improving coordination of logistics operations at different fields, simultaneously	Creating the logistics and emergency operations center	The NCS
Equinor & ENI Norge	Cost-effectiveness; Integrated logistics operations	Sharing a SAR helicopter; Sharing a standby vessel in the case of emergencies; Sharing OSVs from the Goliat project (planned); Contracting with the additional supply base ASCO	Korpfjell & Goliat
NOFO	Increasing the level of oil spill preparedness; Increasing capacity of OSVs	Recruiting fishing boats for emergency response along the coast; Cooperation with the fishing boats and shoreline preparedness fleet	Goliat
Cooperation along the delineation line:			
Rosneft & Equinor	Developing the field projects located close to each other through sharing resources from both Norwegian and Russian sides; Increasing cost-effectiveness and feasibility of field projects	Cooperation agreement in 2012; Intentions to place orders with Russian shipyards for the construction of ice-class vessels and drilling platforms.	Korpfjell, PL 857, PL 858, Perseevsky field
Rosneft & ENI Norge	Increasing cost-effectiveness and feasibility of field project development.	Cooperation agreement in 2012	Fedynskiy field, Tsentralno-Barentsovskiy block

The BASEC cooperation on information sharing in the Barents Sea may also be extended across the borders to the Russian nearby fields as many of the same conditions are present on both sides of the border.

There should also be opportunities for closer cooperation between the shipping companies and their organizations in Norway and Russia. The NOFO concept on oil recovery may also be integrated into Russian sector cooperation.

As for government SAR and oil recovery authorities the cross-border cooperation is strong, based on long-term agreements, including annual joint exercises. Joint emergency response exercises SAR and oil spill response exercises may also include the vessels hired by the oil companies to facilitate private-government cooperation.

5. CONCLUDING REMARKS

This report is a part of the OPLOG project, which provides knowledge on operational logistics and business models in the Arctic environments and innovative solutions to deal with complexity and turbulence of the High Arctic

This report reflects specifically on the offshore upstream logistics operations and field project development in the Arctic Seas on the Norwegian and Russian continental shelves. The analysis of 10 field cases has provided insight into the development of maritime upstream logistics operations and demonstrated challenges, vulnerability, tasks and factors contributing to the complexity of operational logistics and supply management in the Arctic, as well as looked into the preferences and solutions of oil/gas companies as operators in different settings regarding logistics field and emergency response operations.

The report emphasizes a crucial role of OSVs in implementing offshore activities and providing the resilience of supply chain operations for the development offshore oil/gas fields and emergency preparedness to SAR and oil spills.

On both continental shelves - Norwegian and Russian – the oil companies are striving to become cost-effective when developing field projects in the Arctic areas. The safety of operations and emergency preparedness in field projects are crucial operational criteria. Logistics operations are full of challenges and risks in the High Arctic latitudes. Due to remoteness of operational sites and harsh natural conditions, supply operations require careful planning and management. Larger transport volumes, speed to cover longer distances, ice management and emergency preparedness are in demand. Helicopter transport is a challenge due to long distances and *crew change* may rely on vessel transport or vessels as a helicopter hub. This adds to the functionality demands of the vessels involved. Despite the high requirements for OSVs, the demand for more developed OSVs offering innovative and improved services increases as oil and gas companies are moving northwards and looking for new fields in harsher and more remote localities in the Arctic Seas. The findings have revealed that the recent development of OSVs' design has been a shift towards more multifunctional vessels than pure specialist vessels. The biggest difference and challenge of the Arctic areas in comparison with other offshore field projects is the harsh climate and ice conditions. Therefore, there is a demand for specific services of OSVs such as ice management and ice breaking capabilities, as well as vessel protection from very low temperatures fulfilling the Polar code demands.

The findings have also identified two main factors for providing high quality services by OSVs:

- ability of the vessel to provide a wide range of services over longer distances and, thereby, to ensure its high utilization;

- equipment, which can guarantee stability and flexibility in rig operations, safety for the personnel and environment where operations take place, as well as emergency preparedness.

Added education and training as well as an experienced crew and high-quality onshore support teams are an important pre-requisite for providing good and sustainable services by the vessel.

The report provides an overview over regulatory frameworks by the Norwegian and Russian governments regarding the development of offshore oil and gas fields in the High Arctic latitudes. A number of institutional mechanisms show that the regulatory policies from governments can act as a driver or an obstacle for existing operators and/or new entrants.

The barriers to enter the Arctic market are characterized by high costs and lack of competence that affects the development of the petroleum industry and, therefore, operational logistics. A stepwise approach is needed to stretch the area of operation. The Norwegian government's policy on production licensing and favorable taxation leads also to the emergence of new players and coming new technologies. Economies of scale in providing logistics operations is difficult in the High Arctic areas . The analysis of four cases in the Norwegian Barents Sea has showed that there is a new tendency among the oil Norwegian companies to develop integrated logistics cooperation in order to make offshore field projects more effective by sharing resources among different projects. This include SAR helicopter and ERRV vessels. However, the distances may be too long. In the near future, the oil companies plan to elaborate contracts of sharing supply vessels to be engaged in two or several offshore field developments at the same time. This integrated logistics cooperation allows the oil companies to enhance also emergency preparedness systems to their offshore projects in the Norwegian Barents Sea.

The development of oil and gas field projects in the Russian Arctic has been relatively slow but are gaining speed. The complexity of the Arctic environment, the lack of technologies, ,financial capital and resources are quite typical for any areas of the Arctic, there are several specific factors that have affected the activity of the petroleum industry and, simultaneously, the OSV industry in the Russian Arctic. Our investigation has identified the following institutional factors that influence on the speed of development: '

- the abundance of PSAs by replacing them with investment agreements;
- the distribution of the licenses in the Russian Arctic Seas between Gazprom and Rosneft;
- the imposition of sanctions by USA, EU and several other countries in 2014;
- fluctuating oil prices on global markets and some others.

At the present, these factors considerably suppress the field development on the Russian Arctic shelf. At the same time, we can observe an active development of both Sakhalin projects where oil and gas companies are able to practice even economy of scale by sharing onshore and offshore resources like supply bases, SAR helicopters and OSVs. Acting under PSA terms with the participation of the Russian government, Sakhalin-1 and Sakhalin-2 have provided innovations and technologies for operations in ice and very low temperatures based on the international and Russian experience. Logistics schemes elaborated and tested within both the Sakhalin projects will be of great importance for the future development of the Arctic Russian shelf.

6. SUGGESTIONS FOR FUTURE RESEARCH

In this report we have investigated 10 cases of offshore field project development and logistics operations in the Arctic waters. New fields have recently been discovered with new challenges. Among others, a new hydrocarbon field named "Neptun" has been discovered in the Okhotsk Sea by Gazpromneft-Sakhalin in October 2017 with initial in-place reserves estimated at 255 million tons of oil equivalent (the Sakhalin-3 project)[152]. Further investigation of offshore upstream logistics operations can extend and verify the findings, as well as provide deeper insight into new logistics solutions and upstream logistics management.

In the report, we observed a number of diverse international and national (Norwegian and Russian) institutions, which affect offshore logistics operations in the Arctic areas. However, the Arctic intuitional environment has been changing all the time. Knowledge regarding actual impacts from a variety of institutions and all activities by the petroleum and OSV industries is relatively limited and needs more attention in order to fully understand the role of offshore logistics in ensuring the safety and emergency preparedness of offshore field project development in the Arctic.

More focus on technology and specification of vessels with ice-breaking capabilities would be of value to make a thorough analysis of oil/gas companies' preparedness to any emergencies, oil spills and SAR operations in extremely remote and icy Arctic waters.

A next step would be to investigate the processes of integrated offshore/onshore logistics and the development of cooperation between the operating oil companies in order to make offshore field projects more efficient, effective and simultaneously to enhance emergency preparedness. We can already observe the prerequisites and the companies' actions that have recently initiated

[152] For more information, see http://www.gazprom-neft.com/press-center/news/1166743/

the development of integrated offshore logistics, both between different projects in the Norwegian Barents Sea and between existing and new Sakhalin projects. Therefore, the findings of this report encourage future research to draw on and extend the investigation of the OSVs' role in a broader cooperation within oil regions, including emergency preparedness in the Arctic areas.

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Appendix #1.

The list of the interviewees.

Four face-to-face semi-strucutred longitudinal interviews and several telephone interviews were conducted during the collecting data process for the report. All the interviews were done by the 1st author in the period of June – October, 2017.

All interviewees are experts in the field development of offshore oil and gas projects and some of them have a long experience of working directly in real Arctic conditions. In order to comply with ethical issues, the interviewees' names were omitted, and the companies' names were changed and presented in the following way:

- Norwegian oil company #1;
- Russian oil company #2;
- Russian oil company #3;
- Norwegian shipping company #1;
- Norwegian shipping company #2;
- Norwegian vessel-designer.