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Barents Hot Spots Facility

Pilot Project:

IMPROVEMENT OF THE EMERGENCY OIL SPILL RESPONSE SYSTEM UNDER THE ARCTIC CONDITIONS FOR PROTECTION OF SENSITIVE COASTAL AREAS (CASE STUDY: THE BARENTS AND THE WHITE SEAS)

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- OOO Ramboll Barents
- Murmansk Marine Biological Institute (MMBI)
- State Marine Academy named after Admiral S. Makarov
- Neocos Consulting (UK))
- OOO Industrial Safety Systems

The Project is implemented in consultations with the specialists of:

- FSUE Murmansk Salvage Department
- FSI Administration of the Sea Port Murmansk
- Norwegian Coastal Administration.

ABBREVIATIONS

AC - Arctic Council

AEPS – Arctic Environment Protection Strategy

AMAP – Arctic Monitoring and Assessment Program (Working Group of AC)

Arkhangelsk EO ASPTR FSUE MBASU – Arkhangelsk expedition unit for emergency rescue and subsea operations, Branch of FSUE MBASU

ASF(n) – Emergency unit specialized in oil spill response

Aut – Autumn (time of year in OS simulation)

BASU – Salvage Department

BEAC – Barents Euro-Arctic Council

BO –black oil

CAFF – Conservation of the Arctic Flora and Fauna (Working Group of AC)

CCES – Centre of Operation Control in Emergency Situations

ChAO – Chukotsky Autonomous Okrug

CES - Commission on prevention and response to ES

CLC - International Convention on Civil Liability for Oil Pollution Damage

COU –crude oil (Ukhta sort)

COV –crude oil (Varandey sort)

EC – European Community

DOSC - Duty operation control services

EIA – Environmental Impact Assessment

EMERCOM - Ministry of the Russian Federation of Civil Defense, Emergencies and Elimination of Consequences of Natural Disasters

EMSA – European Maritime Safety Agency

EPPR – Program for Emergency Prevention, Preparedness and Response (Working Group of AC)

ES – Emergency Situations

ESI – Environmental sensitivity index;

FOC – Federal Operational Command

FOS – floating oil storage facility

FSI – Federal State Insitution

FSP – Fire Safety Provision

FSUE – Federal State Unitary Enterprise

FSUE MBASU – Federal State Unitary Enterprise Murmansk Salvage Department

FUND - International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage

GEF – Global Environment Facility

GC –gas condensate (stable)

GOST – State Standard of the Russian Federation

GSC – Group sensitivity concentration;

IALA - International Association of Lighthouse Authorities

IMO - International Maritime Organization

IPIECA – International Petroleum Industry Environmental Conservation Association

IS – Integral sensitivity

ITOPF – International Tanker Owners Pollution Federation Ltd.

IUCN - International Union for Conservation of Nature

JPG - Joint Preparedness Group

JRC – The designated site of each Party where facilities are available to provide requirements to fulfill the provisions of the Plan

KB – Kola Bay of the Barents Sea

MARPOL 73/78 - International Convention on Marine Pollution

MBASU- Murmansk Salvage Department

MCSM – Murmansk Center for Standardization, Metrology and Certification

MMBI – Murmansk Marine Biological Institute;

MNR – Ministry of Natural Resources of the Russian Federation

MP – main pipelines

MRCC – Maritime Rescue Coordination Centre

MRCS – Maritime Rescue Coordination Subcentre

MSD – marine specialized department

MSRA – Methods of Shoreline Restoration Assessment

MUGMS– Murmansk Directorate of Hydrometeorology and Environment Monitoring

N – North wind

Na –naphtha

NAO– Nenets Autonomous Okrug

NCA – Norwegian Coastal Administration.

NCCES - National Centre of Operation Control in Emergency Situations

NEFCO – Nordic Environment Finance Corporation

NOAA – National Oceanic and Atmospheric Administration

NOFO – Norwegian Clean Seas Association for Operating Companies

NOSC – National On-scene Commander. Strike teams provided by the assisting country normally operate under the command of a National On-Scene Commander/Coordinator. The NOSC reports to SOSC.

NSR – Northern Sea Route

NW – North-West wind

NWFD – North-West Federal District of Russia

OGP – oil and gas province

OPC – oil production center

OPRC - The International Convention on Oil Pollution Preparedness, Response and Co-operation

ORP – oil refinery plant

OS – oil spill

OSCAR - Oil Spill Contingency and Response

OSR – Oil Spill Response

OTF – offshore transshipment facility

OWM - Oil Weathering Model

PAME – Protection of the Arctic Maritime Environment (Working Group of AC)

PIA – Particularly important areas;

PINRO – Polar Research Institute of Marine Fisheries and Oceanography;

PLARN – Oil Spill Contingency Plan

POLREP (Pollution Report) – a report of the most current information relating to a pollution incident, including actions taken and progress made during the response;

RF – The Russian Federation

RFEZ - Economic Zone of the Russian Federation;

ROC – Regional Operational Command

RS ES - Uniform State System for Prevention and Response to Emergency Situations

S – South wind

SD – Sustainable Development (Working Group of AC)

SERD - Subsea Emergency Rescue Department

SGC – stable gas condensate

SMRCC - State Marine Rescue Coordination Centre

SNG – stable natural gasoline

SOILJ – Stationary Offshore Ice-Resistant Loading Jetty

SOSC – Supreme On-Scene Commander/Coordinator. The overall Tactical Command is laid upon a designated Supreme On-Scene Commander/Coordinator from the lead country.

SPNR – Specially protected natural reservations;

Spr – spring (time of year in OS simulation)

SSR – Standard seasonal ratios;

SV – support vessel

SW – South-West wind

UNEP – United Nations Environment Programme

US – the United States of America

W – West wind

Win – winter (time of year in OS simulation)

WWF – World Wildlife Fund

YaNAO – Yamalo-Nenets Autonomous Okrug

ZAO – Closed joint-stock company

INTRODUCTION

Presently the Russian part of the Barents Sea attracts special attention both in Russia and in other countries. Implementation of large economic projects related to development of the Prirazlomnoe oil and Shtokman gas and condensate fields, development of transport infrastructure, increase of cargo shipment in the White and Barents Seas is on the agenda.

The Federal Target Programme "Development of the Transport System of Russia (2010 – 2015)" provides for construction of a sea port in Belomorsk, Republic of Karelia, construction of a liquefied natural gas transfer terminal in Teriberka, Murmansk region, and implementation of the project "Complex Development of the Murmansk Transport Hub Infrastructure".

During the recent years the volumes of oil sea transportation from the Russian part of the Barents region along the Norwegian coast have increased several times. In 2002 4 million tons of oil were delivered from Russia to the western market in Europe through the Barents Sea, in 2003 – as much as 8 million tons, and in 2004 – 12 million tons. During the period from 2005 till 2008 the annual volumes of the oil sea transportation were at a level of 9,5-11,5 million tons (Бамбуляк, 2009). In 2009 the volumes of transported oil hydrocarbons exceeded 12 million tons. According to the Federal State Institution "Administration of the Murmansk Sea Port" as much as approximately 10 million tons of oil and petroleum products were shipped from the ports of Vitino, Varandei, Dudinka, Arkhangelsk and Murmansk in the first half of 2010 only.

In August 2010 the tanker "SCF Baltica" with a deadweight of 100 000 tons did a trial voyage along the Northern Sea Route delivering 72 000 tons of gas condensate from Murmansk to China. According to the expert assessments, a vessel can spare up to 45% of time if going along the Northern Sea Route as compared to an alternative route via the Suez Canal. Therefore, the revival of the Northern Sea Route may become one of the largest transport projects of the last decades.

All these facts show that the Barents region will be more and more important for transportation and transshipment of oil hydrocarbons, that, however, under severe Arctic conditions may result in higher risks of emergency oil spills and coast contamination.

Insufficient natural light, low temperature, difficult ice conditions and strong winds may complicate clean-up of a shoreline in case of an emergency oil spill. Therefore, selection of the most efficient means and methods of oil spill response offshore and protection of the most sensible coastal areas is of a special importance. And the environmental factors, oil weathering properties and hydrometeorological conditions in the oil spill area should also be taken into account.

The decision on oil spill response tactics and actions shall be taken as early as on the oil spill response planning stage taking into consideration the net environmental benefit analysis.

The objective of this pilot project is to develop proposals for improvement of the emergency oil spill response system under the Artic conditions by the Russian emergency control forces, port authorities and other special organizations for protection of most sensitive coastal areas.

Project summary is presented in Chapter 7 Draft Recommendations

1 ANALYSIS OF RUSSIAN AND INTERNATIONAL EXPERIENCE IN OIL AND PETROLEUM PRODUCTS SPILL RESPONSE UNDER THE CONDITIONS SIMILAR TO BARENTS EURO-ARCTIC REGION

Apart from high risks of contingency in the harsh Arctic conditions there is a high probability that the timely response to an oil spill will be severely hampered or even impossible for a considerable period of time. In this regard, accident prevention, early warning and application of the most efficient technologies for oil spill response (OSR) become especially important, particularly, under ice conditions.

This chapter presents an analysis of international and Russian OSR experience in the Arctic seas, gives an assessment of international cooperation achievements and, identifies the most important areas for further development.

1.1 Study Area

For a better analysis of international OSR experience in the Arctic seas, besides the Barents Euro-Arctic Region (fig. 1.1), and to incorporate a larger number of accidental oil spills, the study area includes the whole Arctic Region (Table 1.1, fig. 1.2a) as well as areas with physical and climatic conditions similar to those in the Arctic (fig. 1.2a-b). A short description of the selected areas is given below.

Fig. 1.1. Barents Euro-Arctic Region

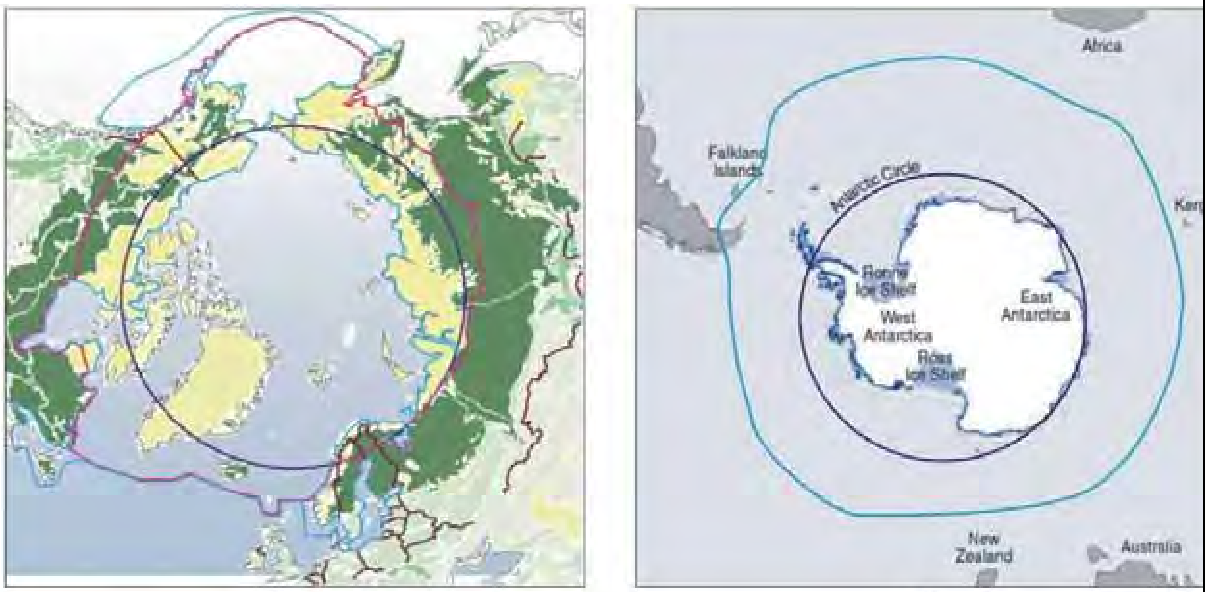
The Barents Euro-Arctic Region comprises the northern areas of Europe and the Russian Federation (RF) and includes territories of Norway (the counties Finnmark, Troms and Norland), Russia (Murmansk and Archangelsk Regions, NAO, the Republics of Komi and Karelia), Finland (the counties Lapland, Oulu and Kainu) and Sweden (the counties Norbotten and Vasterbotten). The territories of the Barents Sea are washed by the Norwegian Sea, the White Sea and the Barents Sea as well as the Gulf of Bothnia in the Baltic Sea. Arctic and Subarctic climate is typical for the most part of the region.

Besides the countries of the Barents Region, the Arctic zone includes, fully or partially, the US, Denmark, Iceland and Canada. At present there is no commonly accepted definition of the Arctic, and each of the countries in the region associates its areas with the Arctic zone. Generally the Arctic region joins the North Pole and includes peripheries of Eurasia and North America, the Arctic Ocean with its islands, and the adjacent areas of the Atlantic and Pacific Oceans. Sometimes the Polar Circle (66° 33′N) is considered to be the south border of the Arctic. In this case the Arctic zone is limited by the borders proposed by AMAP (Arctic Offshore Oil and Gas Assessment, 2009). The areas belonging to the Arctic zone are shown in Table 1.1 and figure 1.2a.

Table 1.1. Arctic areas according to the AMAP assessment

№	Country	Territories
1	Denmark	Faeroe Islands, the territory of Greenland and the surrounding seas
2	Iceland	All the islands and the adjacent water areas
3	Canada	All the territories north of 60°N, the water and coast of the Hudson Bay, the James Bay, the Ungava Bay, and the adjacent waters of the Arctic Ocean
4	Finland	Remote areas of Lapland located north of the Polar Circle
5	Norway	Territories north of 62°N.
6	Sweden	Territories north of the Polar Circle
7	The US	Territories north of the border formed by the Rivers Porcupine, Yukon, Kuskokwim with all the adjacent seas including the Arctic Ocean, the Beaufort Sea, the Bering Sea and the Chukchee Sea with the Aleutian Islands
8	Russia	All the seas and islands of the Arctic Ocean, Murmansk Region, NAO, the Komi Republic (Vorkuta and the adjacent territories), YaNAO (Priuralsky, Taz, Yamal Regions), the Taimyr Peninsula , the Sakha Republic (Allaihovsky, Anabarsky, Bulunsky, Olenensky, Nizhnekolyamsky, Ust-Yansky Regions), ChAO, KAO (Olyutorsky Region of Koryakskiy district of Kamchatka Region) Comment: The officially recognized composition of the Arctic zone has differences)

For the purpose of this study, the geographic areas of the ***Arctic waters*** have been expanded – including additional regions for which low temperatures and ice cover on the sea are typical during a certain period of time. Additionally, the Baltic Sea, the North Sea (Norwegian waters) and the Antarctic were considered. The border of the Antarctic lies along 48-60°S, however, sometimes islands located as far as 37°S are considered as belonging to the Antarctic (fig. 1.2b).



a) б)

The Arctic and Antarctic Polar Circles

The Arctic border according to AMAP assessment

The borders of the Study Area

Fig. 1.2. The study area: a - the Arctic zone; b – the Antarctic zone

1.2 Study of International and Russian Experience of Oil Spill Response in the Arctic seas

During the study period, publications and reports on OSR in the Arctic waters from the US National Oceanic and Atmospheric Administration (NOAA), the Arctic Council Working Group EPPR, International Tanker Owners Pollution Federation (ITOPF), Coastal Guard Administrations of Sweden and Canada, Norwegian Coastal Administration, FSI State Sea Rescue of Russia, and FSUE Murmansk Salvage Department (MBASU) were analyzed.

Based on an analysis of this materials, a list of the largest oil spill incidents between 1970-2009 was completed and is shown in Table 1.2 below. The following criteria were used in selection of the incidents:

- The oil spill took place in the Study area as geographically determined in 1.1;
- The oil spill took place in coastal sea waters or in open seas;
- The amount of spilt oil is equal to or exceeds 200 tons[1];

[1] According to the Resolution of MNR №156 dd. 03.03.2003 “On approval of guidelines for determination of the minimal spill of oil or petroleum products to be qualified as contingency”, the minimal amount of oil or petroleum products to be qualified as contingency for the Arctic Ocean seas is 0.5 ton, and for the Baltic sea – 0.3 ton. NOAA and ITOPF in their analysis of large oil spills around the globe accept discretionary identification of the

– The oil spill took place accidentally (weather conditions, human factor, etc.).

Table 1.2. The list of the largest oil spills in Arctic waters (including the Baltic Sea and the Norwegian part of the North Sea)

№	Year	Spill source	Accident area	Quantity of spilt oil (tons)
1	1970	Tanker Othello	The Baltic Sea, Sweden	60 000
2	1974	Tanker Metula	The Strait of Magellan	54 131
3	1975	Tanker Olympic Dale	The Antarctic	498
4	1975	Tanker Rio Iquazu	The Oresund Strait, the Baltic Sea, Denmark/Sweden	228
5	1976	Tanker Irenes Sincerity	The Baltic Sea, Sweden	500
6	1976	Tanker Golden Star	The Baltic Sea, Sweden	996
7	1976	Tanker Sealift Pacific	The Cook Inlet, Alaska	1 281
8	1976	Tanker Drupa	The North Sea, Tananger, Norway	1 993
9	1977	Production platform Ekofisk Bravo	The North Sea, Norway	27 529
10	1977	Tanker Tsesis	The Baltic Sea, Sweden	1 305
11	1977	Tanker the US	Greenland coast	318
12	1977	Tanker Irenes Challenge	320 km SE of Iceland	33 893
12	1979	Vessel Potomac	Greenland coast	320
14	1979	Vessel Ryuyo Maru No. 2	The Bering Sea, Alaska	842
15	1979	Tanker Antonio Gramsci	The Baltic Sea, Finland	5 500
16	1979	Tanker Kurdistan	Cape Breton Island, Canada	14 000
17	1981	Vessel Sefir	The Baltic Sea, Sweden	498
18	1982	Barge No9	The Kuskokwim Bay, Alaska	300
19	1983	Vessel San Nikitas	The Baltic Sea, The Gulf of Bothnia, Sweden	500
20	1983	Vessel Bellona	The Baltic Sea, Sweden	500
21	1985	Tanker Ekfjord	The Baltic Sea, Sweden	500
22	1985	Tanker Kyudvik Svoboda	The Baltic Sea, Latvia	4 985
23	1987	Tanker Antonio Gramsci	The Gulf of Finland	698
24	1987	Tanker Cabo Pilar	The Strait of Magellan	4 702

minimal amount of the spill, and in some studies it is determined as 200 tons for the purpose to contract the list and select the largest cases.

25	1987	Tanker Stuyvesant	The Alaska Bay	2 000
26	1988	Barge UMTB 283	The Aleutian Islands, Alaska	6 476
27	1988	Oil barge 570	The Beaufort Sea, Canada	220
28	1989	Oil-producing platform Statfjord S	The North Sea, Norway	1 400
29	1989	Vessel Bahia Paraiso	The Antarctic	515
30	1989	Tanker Exxon Valdez	The Prince William Sound, Alaska	40 000
31	1989	Tanker Thompson Pass	Port Valdez, Alaska	231
32	1990	Tanker Volgoneft 263»	The Baltic Sea, Sweden	1 000
33	1992	Oil-producing platform Statfjord	The Norwegian Sea, Norway	900
34	2000	Tanker Alambra»	The Baltic Sea, Estonia	300
35	2001	Tanker «Baltic Carrier»	The Baltic Sea, Denmark	2 700
36	2003	Oil-producing platform Statfjord Draugen	The North Sea, Norway	750
37	2003	Dry-cargo vessel Fu Shan Hai	The Baltic Sea, Denmark	1 910
38	2004	Vessel Selendang Ayu	The Aleutian Islands, Alaska	1 560
39	2004	Vessel Rocknes	The North Sea, Norway, Vatlestraumen area	450
40	2005	Oil-producing platform Statfjord Nornefelte	The Norwegian Sea, Norway	340
41	2007	Vessel Server	The Norwegian Sea, Norway	657
42	2007	Oil-producing platform Statfjord A	The North Sea, Norway	4 000
43	2009	Vessel Full City	The Norwegian Sea, Norway	200

Six accidental oil spills, from the above Table, are considered below; each spill is different with regards to the response measures deployed and the degree of Environmental Impact (EI) [Appendix 1]. Consideration was given to the type and amount of the oil and petroleum products spilt, the oil slick behavior, the impact on the environment, the localization and, response measures.

International experience shows that oil spill response (OSR) operations for an at-sea response are often based on a combination of mechanical oil recovery and two non-mechanical technologies for cleaning or treatment of the spilt oil: dispersant application and/or in situ burning . On completion of OSR operations, clean-up and restoration of the contaminated coastal areas may also be carried out, if required. These methods are further described in the incident description.

According to MBASU and the Norwegian Coastal Administration, no oil spills causing significant impact on the environment have taken place during the previous years in the waters of the Barents and White Seas. One of the largest spills in the White Sea, occurred in Onega Bay on September 1, 2003 whereby, during oil transshipment to the Tanker Zoja-1 from the Tanker Nefterudovoz-57M, the latter sustained a hole in the board. Approximately 54 tons of heavy oil was released into the sea. Thirty km of the coastline were contaminated, and up to 100 kg of heavy oil was collected per 100 meters of shoreline. The damage was estimated at 14.8 million roubles (Бамбуляк, 2005).

In the Russian part of the Barents Sea, three relatively large oil spills have occurred over the past few years. In 2006, 400 tons of oil was released into the sea from the tanks at a military facility at Ara Bay. In 2008, 120 tons of heavy oil was released due to pipeline damage at the facility Kommandit Service. In both cases, the spilt oil was recovered by the owners of the facilities together with OJSC Murmansk Center of Environment Emergency Operations. In January 2009, 10 tons of heavy oil M-100 was released during oil transfer from the storage tanker near the Mokhnatkina Pakhta settlement and impacted the shoreline of Kola Bay. The spilt oil was recovered by FSUE MBASU. All three spills took place at on-shore facilities with a subsequent release of oil into the sea.

The data on accidental oil spills in the Norwegian part of the Barents Sea is shown in Table 1.3. All the incidents took place due to the vessels running aground with a subsequent release of either bunker oil or diesel fuel.

Table 1.3. List of the largest accidental oil spills in the Norwegian part of the Barents Sea (according to the Norwegian Coastal Administration)

№	Year	Spill source	Accident area	Spilt oil amount, tons
1	2000	Vessel John R.	Karsley Commune in Troms County	30
2	2003	Vessel Gudrun Gisladottir	Ballstad village in Vestvogoy Commune, Lofoten islands	60
3	2002	Vessel Skude Jura	Mosey Commune in Finnmark County	20
4	2002	Vessel Murman	Anney Kommune in Norland County	120
5	2009	Vessel Petrozavodsk	Bear Island	75

During the study of the Arctic countries' experiences, the OSR methods and technologies as well as the influence of the local conditions on OSR operations were analyzed, and an assessment was made of the necessity of international cooperation in case of large oil spill response operations.

1.2.1 Methods of Oil Spill Response in International and Russian Practice

There are common approaches in both international and Russian practices with regards to oil spill response at sea. Generally, they can be divided into three groups:

- Monitoring of oil drift on water or ice;
- Containment of the oil slick (stopping oil from reaching the shore);
- Removal and clean-up of the spill (oil recovery from the water surface or shoreline restoration).

Monitoring of oil drift

The purpose of monitoring is to identify the location of oil slicks and the direction in which they are moving. Aerial surveillance is widely used for monitoring of sea surface contamination. However, there are some factors that can hinder aerial surveys of contaminated sea surface, for example, difficult weather conditions (low clouds, low visibility, and strong wind), impossibility of simultaneous coverage of all the survey water area, etc. Satellite radar monitoring is more appropriate for overall monitoring and strategic control of the spill but has limited use for on-scene operational purposes.[2].

[2] Satellite survey is also limited in some ways but less than aviation. For example, with a slight wind of 1-2m/s oil slicks are not identifiable on the background of dark (glazed) sea surface, and with a strong wind of 10-12m/s

Containment and recovery of oil slick

For containment of an oil slick, usually mobile floating barriers – *booms* – are used. With the assistance of booms floating oil is directed to a specially selected location for the follow-up mechanical recovery. Booms are deployed either offshore with the help of specially adapted vessels or along the shoreline. Booms are most effective in calm seas and low current speeds. In rough seas may be lost under the booms. Oil is recovered from the water surface with the help of specially developed oil collectors (skimmers). Their operation is based on recovering oil with rotating brushes, disks or elevating belts or other methods built into the skimmer design, and then pumping it into a temporary storage tank.

Oil spill response

Oil recovery from the water surface

Dispersants application. Dispersants are a group of chemicals that are sprayed on the oil slicks to accelerate the natural process of oil decomposition. They do not remove oil from the water but disperse the oil film on the surface into small drops. The oil becomes more accessible for decomposition by microorganisms and the processes of natural oil decomposition are accelerated. Dispersants are applied with the help of spray nozzles, pumps and flexible pipes, and can be sprayed from a vessel or an aircraft. Operations with the use of dispersants are usually controlled from an aircraft to ensure the efficiency and accuracy of application. Dispersants may be used to treat oil of low and medium viscosity. For high viscosity oil this method is not efficient (IPIECA.., 2001). However there are still controversial attitudes among specialists regarding the use of dispersants (Мансуров, 2004; IPIECA..., 2004) because toxic chemicals may cause additional contamination of the marine environment.

In-Situ Burning. Oil is ignited with an ignition device from a vessel or a helicopter. For successful ignition and burning a certain thickness of the oil film at the moment of ignition is required, as well as a minimal wind speed and sea heaving, and also the oil should not be emulsified (mixed with water) too much. A successful burn can be up to 95-98% efficient, however, in the case of an inefficient burn a mixture is formed from the remaining oil, burning products and soot (NOAA, 2002). Under certain conditions oil burning is more efficient and cost-effective as compared to mechanical recovery, and in some cases in ice conditions it is the only available method. Previously this was considered as emerging technology in the offshore environment, but it has been successfully used extensively to the Deepwater Horizon incident in the USA.

Shoreline cleaning

Washing-off with water. Oil can be washed down into the coastal water surrounded by booms for the following recovery by skimmers. The efficiency of this method decreases with higher viscosity of oil and the depth of its penetration into the soil. It is important to avoid washing-off the oil into the water that was initially clean.

Vacuum systems. To remove large amounts of oil accumulated in ravines, water sources and between boulders vacuum systems are used. However oil-tank trucks with such systems are large and heavy which hamper their access to the oil recovery locations. This method is used in combination with washing-off, for recovery of emerged oil.

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they disappear from the sea surface due to intensive wave stirring. The wind speed between 3 and 8 m/s is ideal for identification of oil spills: in this case the slicks look like dark sports on the light wave-covered surface.

Sorbents. are materials that may absorb oil. Both synthetic and natural materials are used as sorbents, such as polypropylene, polyurethane, moss, tree bark, sawdust, corn glumes. Sorbents may exist in the form of powder, cloth, absorbing booms. The use of sorbents is very limited; they can be used with low-viscosity oils only. Sorbents may be used to fill the space between the rocks to prevent underground leakage. After a sorbent has absorbed the oil it must be collected like other waste.

Manual collection. Manual collection is a labour-intensive and time-consuming process if the contaminated area is large; it includes scraping or wiping with absorbing materials. A large team is required to collect contaminated soil and garbage with absorbing materials, shovels and buckets.

Construction equipment. For quick collection of oil-contaminated soil construction equipment may be used: excavators, bulldozers, etc. However, unlike manual collection, this method produces a large amount of waste; the heavy machines may press oil into the lower layers of soil, destroy vegetation and many of the coastal fauna. Besides, not all locations are accessible for large-size equipment.

In spite of the common approaches to OSR in the Arctic countries, the choice of technology/method of OSR may be limited by the national regulations and standards adopted by the countries and even individual states, for example, as in the US. (Table 1.4).

Table 1.4. National policy in oil spill response and the choice of OSR technology (according to ITOPF)

№	Country	National policy in oil spill response and the choice of OSR
1	Denmark	Mechanical oil recovery methods are preferred[3]. The use of dispersants is possible depending on the specific character of the spill and after compulsory approval by the Environment Agency of Denmark. In the Danish part of the North Sea limited use of dispersants is possible if mechanical recovery cannot be used. In the Danish sector of the Baltic Sea the use of dispersants is prohibited.
2	Iceland	Containment of an oil spill as close to its source as possible is the main priority. Dispersants are acceptable as an addition to mechanical recovery if its use is limited or impossible. Permission from controlling authorities is required to use dispersants.
3	Canada	The first-priority task is pumping oil products out of a damaged tank of the vessel, and then mechanical oil recovery from the water surface is carried out if the weather conditions are favorable. Dispersants and burning play a secondary role. Before using dispersants testing is required; if the testing is successful, permit may be obtained from controlling authorities to use dispersants. Protection of especially sensitive areas with booms is prioritized to mechanical recovery, washing-off with water, steam treatment etc. Depending on the local conditions methods of biological remediation can be used.
4	Finland	Mechanical oil recovery methods are preferred. Dispersants are not used.
5		Containment of an oil spill and recovery as close to its source as possible is the main priority. Dispersants are used in addition to

[3] Mechanical recovery methods include all recovery methods except for dispersants and incineration

	Norway	mechanical recovery (the choice of this technology is based on environmental feasibility analysis). The possibility of dispersant use is compulsorily described in every OSR plan. Without prior assessment dispersants may only be used with permission from the Norwegian Coastal Administration.
6	 Sweden	Mechanical recovery methods are prioritized. Dispersants are not used.
7	 US	Containment and mechanical recovery of oil spills are prioritized. Many states specify zones where dispersants and oil burning is allowed without additional approval. Generally, such zones are located within three nautical miles of the shore with prevailing depths of 10 meters and more.
8	 Russia	Containment and mechanical recovery of oil spills is prioritized. Dispersants and oil burning in situ are allowed in certain cases after the appropriate permit is obtained.

As a general rule, in oil spill response a combination of different technologies is used. However, international experience has shown that each oil spill is unique. In the Arctic, the use of each of the above methods or a combination of response methods may be considerably limited or even impossible due to the harsh natural conditions.

1.2.2 Restrictions for Oil Spill Response Operations in the Arctic Waters

Time is critical for any OSR methods in the Arctic. As soon as oil is released into the water, it begins spreading, evaporating, emulsifying, or breaking into separate slicks. Usually in the course of time the spilt oil becomes more difficult to monitor, contain and collect. Consequently, quick mobilization of trained personnel and deployment of OSR equipment is of great importance for an efficient response to oil spills.

In all regions of the Arctic, there are periods when due to difficult weather and ice conditions, oil spill response in a safe and efficient manner is not possible. Typical Arctic conditions and the associated restrictions for use of OSR technologies are shown in Table 1.5. However, as international practice shows, sometimes extreme natural conditions may multiply the rate of oil dispersion in stormy weather or, for instance, ice may serve as a natural barrier preventing oil spread.

Besides the climate conditions, the speed and efficiency of response is largely dependent on the fact that accidents often happen in places far away from settlements, with underdeveloped infrastructure or without any infrastructure at all. This creates additional difficulties and requires more time to deliver OSR equipment, deploy OSR personnel, ensure their safety and provide them with the required supplies.

The combined impact of these restricting factors may make oil spill response almost impossible in the Arctic conditions for lengthy periods of time.

1.2.3 Lessons Learnt

Statistically, large oil spills occur each 2-3 years. In spite of gradual strengthening of environmental requirements and safety regulations at sea, both at national and international levels. There are no guarantees that there will be no accidents causing oil spills in the Arctic seas.

Oil spills have been and will be an inevitable part of the operations associated with oil and gas production, oil transportation and transshipment. However, it should be noted, that oil spills occur not only during accidents from oil wells and tankers, but also from passenger and fishing vessels, that use oil products as fuel, and at petroleum storage tanks located in the sea port areas.

Case histories have shown that there is no direct correlation between the amount of oil spilt and the scale of consequences. The oil properties, proximity to the shore and weather conditions in the accident area are important factors that need to be considered. For example, the release of 28,000 tons of oil at the production platform Ekofisk Bravo in 1977 did not have any adverse impact on the environment as the oil was naturally dispersed under the influences of both wind and waves, which preventing it from reaching the shore. At the same time, in 1979, a small oil spill near Vardo, north Norway (the Barents Sea) had very serious consequences for the environment. The slick was so small that it was not identified, however, the spill happened at a period of time when Varanger fjord was full of sea birds. As a result of the incident, approximately 10,000 birds died (Бамбуляк, 2005).

The lessons learnt during OSR at sea enables us to conclude that the main OSR objectives is for containment or deflection of the oil slick to prevent it from impacting the shore and for oil recovery at sea.. An oil spill has the greatest potential for harm to the environment and economy if the oil reaches the shoreline.

Table 1.5.Oil spill response restrictions in the Arctic conditions

Conditions	Restrictions for use of OSR technologies in the Arctic conditions			
	General restrictions	**Containment/ Mechanical recovery**	**In situ burning**	**Dispersants**
Sea ice	It may hamper access to the spill area and complicate finding and monitoring the slick. Ice may limit vessel maneuverability and deployment of oil recovery devices and booms. Vessels without ice-reinforcement of the hull must not be used in severe ice conditions.	Boom barriers may be moved or damaged by ice. Crushed ice may block pumps and decrease the efficiency of oil skimmers.	Ice slush[4] may decrease the efficiency of oil burning or impede oil ignition. Deployment of fire resistant booms may be complicated or impossible.	Oil under ice is not accessible for dispersants.
Wind/Rough sea	Strong winds and waves may decrease the efficiency of vessel and equipment necessary for the removal of oil from the sea surface. Strong winds may hamper aircraft operations or make them unsafe.	Strong winds and waves may unanchor booms. Waves over 2-3 meters high generally restrict the use of booms.	In case of strong winds and waves oil burning in situ is generally unsafe and practically impossible.	In conditions of strong wind spot dispersal is extremely complicated as the dispersant is blown off track by the winds.
Temperature	Long periods of low temperature impact personnel safety and require more frequent rotations of shifts.	Icing of booms and OSR equipment is possible. Increased viscosity of oil makes its collection and pumping more difficult.	Extreme cold may hamper ignition or make it inefficient and may cause delayed burning or extinction of fire.	Low temperatures and higher viscosity may decrease the efficiency of dispersants.
Limited visibility	Low visibility (including the Polar Night period in the High North) puts restrictions on involvement of vessels and aircraft in OSR operations and makes monitoring of oil drift more complicated.	Deployment and operation of equipment requires adequate visibility.	Ignition from aircraft and/or aviation monitoring requires good visibility.	Spot dispersal of dispersants requires good visibility.

[4] Ice slush is a thick layer of small ice crystals on the water surface

Shoreline clean-up and restoration operations may last from several weeks to 2-3 years depending on the spill scale and local conditions.

Treatment of solid and liquid oily waste generated in the course of OSR operations may become a serious problem. This problem is particularly relevant in areas where the required facilities for oily waste treatment or storage according to environmental standards are unavailable. International experience shows that there is no direct link between the amount of spilt oil and the resultant waste. The oil properties and the selected response strategy play a crucial role in the amount of waste generated during a spill incident. For example, during the tanker Exxon Valdez incident in 1989 about 40.000 tons of oil were accidentally released into the waters of Prince William Sound, Alaska. The OSR operations were carried out in remote and inaccessible areas and as a result, rather than collect oil-contaminated soil, a decision was made to flush the water off the shoreline. However, the response operations and the amount of domestic waste generated by the responders resulted in about 45.000 tons of solid waste being produced; the majority of which was domestic waste not contaminated with oil. The waste was transported by sea to Oregon 5.000 km from where it was collected. On the contrary, in the course of a relatively small oil spill (1.500t) during the incident on the vessel Selendang Ayu in 2004 near Aleutian Islands 50km of shoreline were contaminated and 8.500 tons of oil-contaminated soil were collected which were then transported by sea 8.000 km away from the place of incident. And, finally, during the incident involving the Metula with a spill of 54.000 tons of oil, approximately 250 km of shoreline were contaminated. However, not a single ton of waste was collected because no OSR operations were carried out at all (Guidelines…, 2009).

Natural conditions in the area of the spill incident play an important if not crucial role in the success or not of the whole OSR operation. All the challenges that OSR personnel have to face in the southern seas increase many times in the course of oil spill combating in the Arctic.

It is difficult for one coastal country to combat an oil spill in the cold Arctic waters at the scale of consequence comparable to, for example, the Exxon Valdez incident. That is why, only through cooperation between neighbouring countries and the general cooperation of the Arctic states, can the optimum results be achieved in the area of oil spill prevention and response.

1.3 Cooperation of the Barents Euro-Arctic Region Countries in Oil Spill Prevention and Response

International cooperation in OSR, including that in the Arctic seas, is based on the documents developed and approved by the International Maritime Organization (IMO):

- The International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990 (Convention OPRC);
- International Convention on Civil Liability for Oil Pollution Damage, 1992. (CLC);
- International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1992. (FUND);
- International Convention on Marine Pollution of 1973, amended by Protocol of 1978 (MARPOL 73/78);
- International Convention on Civil Liability for Bunker Oil Pollution Damage, 2001.

Ratification of IMO conventions by the Arctic states is shown in Table 1.6.

Table 1.6. Ratification of IMO conventions by the Arctic states

№	Country	MARPOL 73/78	CLC	FUND	OPRC	Bunker
1	Russia	✓	✓	✓	✓	✓
2	Norway	✓	✓	✓	✓	✓
3	Sweden	✓	✓	✓	✓	
4	Denmark	✓	✓	✓	✓	
5	Finland	✓	✓	✓	✓	✓
6	Iceland	✓ Annex 1-3,5	✓	✓	✓	
7	Canada	✓	✓	✓	✓	✓
8	USA*	✓ Annex 1-3,5,6			✓	

* Whilst the USA is not a signatory to the CLC and Fund conventions they have established the Oil Spill Liability Trust Fund (OSLTF).

In addition to the IMO international conventions, the relations between the Arctic states, in respect of OSR, are often based on bilateral or multilateral agreements and memorandums of understanding. These agreements are quite specific and, as a rule, their main aim is the development of joint action plans in case of oil spill in specific areas. As a rule, such plans specify mutual cooperation in response to large (when the resources of one of the parties are not sufficient) or transboundary oil spills: warning and communication arrangement; use of resources from the neighboring countries and; establishment of joint operation management office, etc. The countries of the Barents Euro-Arctic Region (BEAR) are parties to several agreements of this kind, for example:

- The Conversions on the Protection of the Marine Environment of the Baltic Sea Area, 1992/2000. (Helsinki Agreement; the member states are: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Sweden, Russia, European Community [EC]);
- Agreement between Denmark, Finland, Iceland, Norway, and Sweden on joint response to sea contamination with oil and other hazardous substances, 1983. (Copenhagen Agreement);
- The Bonn Agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances, 1983. (the member states: Belgium, Denmark, France, Germany, the Netherlands, Norway, Sweden, the UK and EC);
- Quadrilateral agreement between Russia, Finland, Sweden and Norway on cooperation for Emergency Prevention, Preparedness and Response in the Barents Euro-Arctic Region, 2008;
- Bilateral agreement between Russia[5] and Norway on joint oil spill response in the Barents Sea, 1994.

The member states have agreed, taking into account their capabilities and available resources, to cooperate in any oil spill response in the area specified by the relevant agreement if it is justified by the scale of the incident. The agreeing parties hold an annual coordination meeting to exchange information and discuss results and further plans.

[5] Besides cooperation with the countries of the Barents Euro-Arctic Region Russia is also a member of the following OSR agreements:
- Bilateral agreement between Russia and the US on joint oil spill response in the Bering and the Chukchee Seas (1989);
- Bucharest Convention (the Black Sea basin states) was signed in 1992, and ratified by Russia in 1993;
- Memorandum of Understanding between Russia, Japan, Korea and the PRC (North West Pacific Action Plan);
- Frame Convention of the Caspian marine environment protection signed in 2003 by Russia, Azerbaijan, Iran, Kazakhstan and Turkmenistan came into force in 2006.

To strengthen the cooperation, the member states carry out regular joint OSR exercise to test the systems for warning and communication, determine the time required for mobilization of resources, to train personnel, and to test the available equipment and approval of its use by the member states.

The success of international exercising was proven during the well-coordinated joint oil spill response between the rescue forces of Germany, Denmark and Sweden in the Baltic Sea during the incidents involving the tanker Volgoneft 263 (1990), the dry-cargo vessels the Baltic Carrier (2001) and the Fu Shan (2003).

1.3.1 Bilateral Cooperation between Russia and Norway in Oil Spill Prevention and Response

1.3.1.1 Cooperation in Monitoring and OSR

The cooperation between Russia and Norway in marine environment protection from oil contamination has existed for over 15 years and is based on Cooperation Agreement for Oil Spill Combat signed by the Governments of Norway and Russia in 1994 (Resolution by the Russian Government No. 545 dated 24.05.1994). The major provisions of the Russian-Norwegian Agreement are described in Chapter 2. Under the Agreement a Joint Contingency Plan in the case of oil contamination in the Barents Sea was developed. These documents determine the policies and the framework for cooperation between the relevant authorities of both countries with regards to combating oil contamination and organization and implementation of regular joint meetings and exercises. The Joint Contingency Plan is amended and updated annually.

In 2003, the Ministry of Fisheries and Coastal Affairs of Norway and the Transport Ministry of the Russian Federation initiated cooperation in developing a system of mutual warning and information exchange to improve navigation control in the Barents and Norwegian Seas and early alert in case of emergency. In 2006 the parties signed a Memorandum of Understanding, the main provisions of which are as follows:

- Upgrade of the existing and development of new vessel traffic management systems including information system of vessel traffic in the Barents Sea (Barents VTMIS) by each of the parties according to regulations of IMO and International Association of Lighthouse Authorities;
- Information integration for transmittal of approved data on traffic in the adjacent sea areas covered by Barents VTMIS;
- Creating a system of traffic monitoring and information of the Barents Sea. This system is partially based on data exchange in the Automatic Vessel Identification System between the vessel traffic control centers in Murmansk and Vardo.

Joint exercises are held in Russia and Norway (fig. 1.3) during which specialized oil spill combat forces exchange experience and acquire skills of practical interaction. In the past, such exercises were held every two years, however, lately they take place annually. Until 2008 the exercises included OSR and search-and-rescue operations. Since 2008, on the recommendation from the Russian Federation, separate exercises have been held in rescue and oil spill response.

Fig. 1.3. International OSR exercise on the Kola Bay coast, 2008-2009

In 2009, the 4th international exercise of rescue forces of the BEAR countries Barents Rescue 2009 was held in the Murmansk Region. The international exercises Barents Rescue are held under the quadrilateral Agreement between the BEAR countries of Cooperation for Emergency Prevention, Preparedness and Response in the Barents Euro-Arctic Region (the Agreement is described in a more detail in Chapter 2) and plays an important role in the joint training of rescue forces in the four countries. For successful implementation of the Agreement, the Parties established Interim Joint Committee on Rescue Cooperation in the Barents Region. Annually, or as required, the Committee meets to plan and coordinate the cooperation required as well as to assess the implementation of the Agreement.

The first Barents rescue exercise was held in Sweden in 2001, then in 2005 in Norway and in 2007 in Finland. 384 people participated in the exercise in 2009, including rescue forces, fire brigades; 47 units of rescue and firefighting equipment were utilized in the exercise. In the course of Barents Rescue 2009, joint actions of the rescue forces of the Murmansk Region and Norway were exercised during the search-and-rescue operations at sea; the exercise scenario involved a dry-cargo vessel's collision with an unidentified underwater object in the Varanger Fjord, the Barents Sea, with a resultant fire onboard the vessel and accidental oil spill into the water. It is anticipated that the next exercise, Barents Rescue, will be held in Sweden in 2011.

Within the framework of Russian-Norwegian cooperation, a group of joint response was established: the Russian side is represented by Gosmorspassluzhba of Russia (State Sea Rescue Department) and FSUE MBASU, and the Norwegian side – by the Norwegian Coastal Administration. The functions of the groups include organization of exercises, communication testing, discussion of accidents on each side, planning work for the next year etc. Among the active participants of these joint activities, there are the Committee of Nature Management and Environment, the Department of the Ministry for Emergencies of Russia in the Murmansk Region, and the Ecocenter Group whose functions include rescue preparedness and OSR at onshore facilities. On the Norwegian side, the major participants are Ministry of Fisheries and Coastal Affairs of Norway, Norwegian State Pollution Control Authority, and NorLense Beredskap.

In addition to the authorities responsible for oil spill prevention and response, there are non government organizations who take an active part in the development of cooperation in this sphere, for example, WWF (World Wildlife Fund).


a) b)

Fig. 1.4. OSR exercise: a - WWF volunteers training OSR methods in Vardo, Norway, March 2006: b – OSR exercise with participation of WWW volunteers near the settlement Belokamenka, Murmansk Region, June 2006.

In 2005, under the auspices of WWF, the project "Clean Coast" was launched to train Russian and Norwegian volunteers, in the various response options of shoreline clean-up in case of accidental oil spill. The program included a theoretical course with a basic knowledge of oil properties and its behavior in the case of a spill, impact on the environment, OSR methods, HSE etc. The students applied their acquired knowledge in practical training during the annual OSR exercises (fig. 1.4). In January 2007, the WWF volunteers had their first experience of a real incident in Norway where they took part in shoreline clean-up as a result of the incident involving the cargo vessel Server. 130 volunteers were involved in the OSR operations; they collected 230 tons of heavy oil and contaminated debris. For the duration of the training program in the Murmansk Region, which has been running for several years, over 200 people have been trained including 20 specialists from the Department of the Russian Ministry for Emergencies in the Murmansk region who have been trained to act as leaders of volunteer teams for OSR operations. However, most of the volunteers are students of Murmansk universities.

In June 2010, the Government of Murmansk Region and Rogaland County signed a Protocol of Intent to develop cooperation in various fields. Particular attention was paid to the issue of facilitating the strengthening of cooperation between the authorities responsible for oil spill response, for example, FSUE MBASU and Norwegian Clean Seas Association (NOFO), and support for the project "Center of Safety and Rescue Operations in the Arctic". It is anticipated that by the end of 2010, Declaration of Cooperation between Murmansk Region and Rogaland County will be signed.

1.3.1.2 Participation of Statoil ASA in Improvement of Oil Spill Response System in Murmansk and Arkhangelsk Regions

The Norwegian company Statoil ASA has made a contribution to the development of cooperation and improvement of oil spill prevention and response systems in the Murmansk and Arkhangelsk Regions. The following projects are some of the major work undertaken to date:

Projects in the Murmansk Region

Statoil ASA gave support to the Committee of Nature Management and Environment of the Murmansk region in developing the "Integrated Action Plan for Environment Safety of Coastal Areas and the Adjacent Arctic Sector" and also financed a project to establish an integrated oil spill response system in the Murmansk Region. Phase I of the Project includes 3 components:

- Supply of modern OSR equipment to FSUE MBASU and training of FSUE MBASU personnel;

- Establishment and equipping of a laboratory at the premises of the Murmansk Center of Standardization, Metrology and Certification (MCSM) for characterization of oil and weathering studies of oil, expert support of the Norwegian Institute SINTEF in the area of modern research methods and, training of laboratory personnel;

- Installation of software OWM (Oil Weathering Model) and OSCAR (Oil Spill Contingency and Response) for simulating the weathering of oil and assessment and applicability of various OSR technologies at the Murmansk Directorate for Hydrometeorology and Environment Monitoring (MUGMS) premises and, training MUGMS personnel in the use of the software.

A distinctive feature of the oil studies at the MCSM laboratory, which makes them different from the traditional ways of oil characterization according to the RF GOST, is the weathering studies of oil under different sea conditions. This included taking into consideration water and air temperatures, wind speed and, wave height. Research was carried out with both fresh oil samples and with samples after preliminary processing (topping)[6]. This process simulates samples similar to evaporated oil under natural weathering conditions for 1 day, 1 week and 1 month after the spill.

The results are used for simulating behavior of a certain oil type under pre-set hydro-meteorological conditions and selection of OSR methods with the help of OWM and OSCAR software. According to the Project objective, based on the obtained data FSUE MBASU, this allows for identification of the most appropriate response methods and resources for oil spill response.

The structure of the integrated OSR system can be described as follows:

- FSUE MBASU transmits the information on oil spill to MUGMS and MCSM;
- MCSM provides MUGMS with the properties of the oil type;
- MUGMS uses the received data and forecast wind speed and direction for the required period of time in the area of interest, to simulate the oil weathering processes with the help of OWM and OSCAR software;
- The OWM results are transmitted as text files and diagrams to MCSM;
- The OWM and OSCAR results are transmitted to FSUE MBASU as slides showing the location and transformation of the oil slick.

To implement the above interaction, it is necessary to establish a database on the physical and chemical properties of all oil types transported in the Barents Sea and Kola Bay. However, at present only 2 types of Russian oil have been characterized and studied for weathering properties at the MCSM laboratory.

To carry out a complete analysis of just one oil sample takes approximately 4-5 weeks. If a database can be made available, then it will be possible to analyze an oil sample by three parameters only: density, viscosity and hydrocarbon composition. This will allow identifying the oil type in a shorter period of time. In case of an accidental oil spill, with

[6] Oil topping is extraction of light fractions of oil.

prompt information about the vessel, its location and weather conditions, forecasting the oil slick behavior can be made in a shorter period of time.

Presently, implementation of Phase II of the project has already begun, with the support from Statoil ASA, which includes procurement of additional equipment to expand the possibilities of the MCSM laboratory and training of MUGMS personnel to improve the quality of simulation. In addition, it is planned to continue establishing a database of properties of the different types of oil transported in the Barents Sea and Kola Bay.

Projects in the Arkhangelsk Region:

Statoil ASA provided support to supply a modern mobile laboratory to Arkhangelsk within Phase I of the implementation of the "Common System of Regional Environmental Monitoring for Control and Combat of Pollution and Risks of Potential Negative Industrial Impact on Environment". The laboratory will carry out sampling to identify the parameters of pollution in-situ on a real-time basis. This will allow for identification of the source of pollution and also, the most appropriate response measures.

Statoil ASA has facilitated the sharing of Norwegian experience in prevention of potential conflicts between oil and gas and fishing industries and also financed expert and technical support, round-table discussions and seminars in environment monitoring to discuss possible solutions for future industrial and oil and gas projects in the Arkhangelsk Region.

At present, Statoil ASA, jointly with the Administration of the Arkhangelsk Region, is preparing an Action Program for Phase II. The Program will include development of plans for: laboratory work and analysis procedures; personnel training and; creation of information portal at the website of the Arkhangelsk Region Administration for the integration of environment status information received from all stations of environment monitoring.

1.3.2 Achievements of the Arctic Council and its Working Groups

The Arctic Council (AC) is an international regional body whose purpose is to promote cooperation in environmental protection and sustainable development of circumpolar regions. The Declaration of its establishment was signed on 19 September, 1996 in Ottawa, Canada by representatives of the eight Arctic states: Denmark, Iceland, Canada, Norway, Russia, USA, Finland and Sweden.

The matters related to international cooperation in Arctic Environment Protection Strategy (AEPS) were given under the aegis of the AC. To achieve the goals and coordinate the work in each of the areas, 6 Working Groups were established:

- Arctic Monitoring and Assessment Program (AMAP);
- Arctic Contaminants Action Program (ACAP);
- The Emergency Prevention, Preparedness and Response (EPPR);
- Conservation of the Arctic Flora and Fauna (CAFF);
- Protection of the Arctic Marine Environment (PAME);
- Sustainable Development (SD).

Taking into account the intensive development of oil and gas activities in the Arctic the AC priorities in oil spill prevention and response are as follows:

- Research, assessment and development of recommendations for maintenance of oil pollution prevention system and reduction of the impact on the environment;
- Promoting the development of cooperation between the Arctic countries in prevention and combating of oil spills in the Arctic, in particular, in the Barents, the Bering and the Chukchee Seas.

The major achievements of the AC in this area are described below.

1.3.2.1 Assessment of Offshore Oil and Gas Activities in the Arctic

In 2007, under the leadership of AMAP, the AC Working Groups prepared a report "Assessment of Oil and Gas Activities in the Arctic", with an analysis of the existing, and forecast of future impact of oil and gas industry on, the environment, economy and social spheres of the Arctic countries. The report is based on the AMAP research findings of 1997/1998. The report gives the following recommendations[7]:

Social sphere:

- The public, and primarily the local population and indigenous people, should be involved in the decision-making process. Before the beginning of oil and gas fields development and construction of new facilities, consultations with the local population must be arranged so that their rights and interests are considered in the best possible way and the negative impact of the expected activities is reduced as much as possible.
- When planning economic activities, attention should be paid to improvement and long-term support of social sphere, such as, for example, construction of schools, medical centers, development of infrastructure and other benefits that the local population can use even after the termination of the economic activities in the region.

Environment:

- Measures must be taken to provide compulsory strict control over oil and gas activities in vulnerable regions, especially in the periods of valuable species' presence in the area of economic activities. The Arctic countries' governments should take an active part in this process;
- Seasonal restrictions should be introduced for activities, if necessary;
- The need for establishing additional conservation areas closed for economic activities should be considered;
- In planning OSR operations, one should take into consideration the sensitivity mapping data on the areas especially vulnerable to oil pollution

Legislation:

- Laws and regulations adopted by the Arctic countries should be revised from time to time and amendments should be made, as necessary, to reduce the negative impact of oil and gas activities and to increase their positive effect on the environment and social sphere;
- The law should stipulate requirements for the use of best industrial and international standards;
- The system of control over compliance with standards and regulations in the Arctic countries should be improved;

[7] Some of the Arctic countries are already implementing all or some of the recommendations.

- Compliance assessment of economic activities against local standards and regulations should be carried out;
- The guiding principles of oil and gas activities and the legal foundation of planning and control over OSR operations in the Arctic sea should be improved, if necessary, to reduce the negative impact on the environment;
- Oil and gas companies should bear financial responsibility for risk reduction, oil spill response, re-vegetation of oil-contaminated areas, and co-finance the study of oil and gas activities impact on the environment and monitoring;
- Carrying out impact assessment and risk assessment are mandatory; their procedures and principles in different Arctic countries need to be harmonized;

Technologies:

- The best available technologies should be used at all stages of economic activities;
- If necessary, environment monitoring in real time must be carried out and the best science-based methods must be used to prevent negative impact of seismic exploration on sea mammals;
- Transportation of hydrocarbons in the Arctic must be carried out with strict adherence to safety standards, by the use of double-hull ice-class tankers and, the use of modern monitoring systems and information transmittal on vessel traffic etc;
- The maintenance of oil and gas pipelines must be carried out by modern methods of monitoring and pipeline condition inspection (detection of corrosion, damage etc);
- Oil and gas companies must pursue the policy of reduction of emissions and pollutants discharge including aiming towards “zero discharge”, improve process water treatment systems and oily waste management, use materials and chemicals that are the least hazardous to the environment etc;
- Restoration of oil-contaminated areas is needed to minimize the environmental consequences of economic activities.

Prevention and OSR:

- Possibility for oil and gas activities and oil transportation should be reconsidered in the areas where oil spill response is very limited or impossible;
- Emergency preparedness should be maintained at a high level including revision and improvement of OSR plans and OSR exercises. The operators, rescue authorities at local, regional, national and international levels should cooperate in vessel traffic control, information exchange and organization of timely response;
- OSR resources must be permanently ready; as required, the resources must be upgraded and enforced. OSR technologies must be improved, especially for oil spill response under ice conditions. In the Arctic, storage facilities are needed for modern OSR equipment to lessen the time taken for equipment delivery to the area of oil spill;
- The Arctic countries should assess their own ability to provide full financial support for prevention, preparedness and OSR taking into account the control over implementation of these measures;
- Further studies of oil behavior during a spill at sea, especially under ice conditions, are needed and OSR technologies must be improved;
- In the course of OSR operations in the Arctic, full-scale testing, confirmation of laboratory results of testing new OSR methods, oil weathering modeling etc. are necessary. The personnel and appropriate laboratory equipment should be mobilized quickly enough to arrive at the oil spill scene;
- To continue research and determination of the regions that are the most sensitive to oil spills (if necessary, increasing the use of computer-based models for calculations of the oil slick drift and transformation) and include them into the OSR priority areas.

1.3.2.2 Arctic Offshore Oil and Gas Guidelines

In 2009, the AC published the Arctic Offshore Oil and Gas Guidelines addressing, first and foremost, the authorities of the Arctic countries, representatives of oil and gas industry planning or implementing activities in the Arctic, as well as all the stakeholders. The guidelines stipulate a number of environmental protection measures and procedures that are mandatory or recommended in the course of offshore oil and gas projects in the Arctic. The Guidelines take into consideration the specific character and different standards of environmental protection in each of the eight Arctic countries and the difference in the division of responsibility between operators and control authorities in the different countries. Which is why, the goal of the AC is to assist control authorities in developing environmental protection standards acceptable and mandatory for all offshore operators working in the Arctic.

According to the Guidelines, for the purpose of environment protection, all offshore oil and gas projects in the Arctic should be based on the environment harm prevention principles "the polluter pays", continuous improvement of management and control tools, application of the best technologies and the sustainable development principle (biodiversity protection, risk minimization, involvement of the public into making environmentally significant decisions etc.).

The Guidelines make evaluation of the existing and potential impact from oil and gas activities on the environment and population of the Arctic. According to the Guidelines, the Arctic states must:

- Take into consideration the local peculiarities and local/indigenous population knowledge in the decision-making process;
- Facilitate the participation of the local population, indigenous peoples and the general public in making environmentally significant decisions;
- Insist on and, if necessary, demand the oil and gas operators to include measures for environmental and cultural heritage protection into design and construction of oil and gas facilities and their operation;
- Identify the natural areas especially sensitive to human impact and strictly control oil and gas activities in such areas;
- Identify economically valuable biological resources and take into consideration their sensitivity to human impact in planning and making project decisions.

The Guidelines analyzes the principles and gives recommendations for the main environment protection procedures such as environmental impact assessment, environment monitoring, environment risks assessment and management, safe waste management, and environmental support at all stages of oil and gas projects from planning through construction, operation, shutdown of the facility etc. Special attention is paid to oil spill prevention and response. According to the Guidelines, the operators must meet the following requirements:

To be permanently ready for contingency response;

- To assess contingency risks, their consequences and identify the best response strategy;
- To include contingency preparedness measures into environment protection plans and to implement them at all stages of oil and gas project implementation;
- In the case of a spill, to recover oil as close to the spill source as possible;
- To pay special attention to a spill response under ice conditions including availability of the appropriate equipment and vessels;
- To ensure health and safety protection for personnel involved in OSR operation;
- To provide personnel with appropriate training for participation in OSR operations;
- For authorities to promote international cooperation in the OSR sphere.

Planning of OSR operations is an important part of safety management in any oil and gas project. OSR plans must include, as a minimum, the following information:

- Clear description of alert and notification actions in the case of oil spill detection, specifying the officials and authorities responsible for decision making, communication systems etc.;
- Response strategies including the description of OSR technologies (oil containment and recovery on water, onshore and under ice conditions, the use of dispersants or in situ burning), OSR resources;
- Description of response in case of a small oil spill;
- Description of first aid to any injured persons;
- Description of the area where OSR operation is expected to take place (weather conditions, prevailing depths etc.);
- Description of oil spill monitoring system (the use of satellite and aircraft data);
- Maps of environmental sensitivity, specifying the priority protection areas and methods of biological resources protection;
- Description of the system for transportation, storage, and utilization of oily waste produced in the course of OSR operations.

In addition, planning should take into consideration extraordinary/emergency situations, for example, a fire, explosion, personnel fatality, emission of toxic and explosive gases etc.

If presence of icebergs or pack-ice is typical for a certain area of a platform operation, the operator is required to develop an ice management plan specifying measures of the platform protection from damage. The plan must also describe monitoring, ice situation assessment, risk assessment, procedures for response teams mobilization etc.

According to the Guidelines, the development of a holistic Arctic oil spill response plan will allow for clear delineation of responsibilities between the countries, identify the leading response group in each region and the response groups that may provide assistance to other countries in OSR operation. This will allow for coordinating joint efforts, of the Arctic countries, in oil pollution prevention and combating and, increase the efficiency of joint OSR operations in general.

1.3.2.3 EPPR Activities

EPPR (Emergency Prevention, Preparedness and Response) is a Working Group of the AC, which contributes to cooperation of the Arctic countries in emergency prevention and response in the Arctic. EPPR promotes prevention and minimization of consequences of radiation accidents, pollutants emission, and natural disasters.

EPPR is not an organization that deals with the practical actions of an emergency response. Rather, the member states regularly exchange experience and technical information, participate in research work, arrange joint exercises and, develop guidelines for OSR operations, risk assessment etc. Among the EPPR implemented oil spill prevention and response projects, the following are of note:

Field Guide for Oil Spill Response in the Arctic Waters, 1998.

Summary: The Guide takes into consideration the world's practical experience and includes recommendations for OSR operations in Arctic waters taking into account the specific climatic and physical-and-geographic conditions of the region. The Guide analyzes different OSR strategies and technologies under ice conditions for open and coastal sea waters, on rivers and lakes. The Guide is written in an intelligent manner and is for use by technical experts, OSR personnel and authorities. A decision was made to publicize the international experience compiled in the Guide, at national level, to unify the activities in the event of a possible OSR operation on an international scale. The Guide has been completely translated into Russian and partly into French, Finnish, Swedish and Inuktitut[8].

Circumpolar Map of Resources at Risk from Oil Spills in the Arctic, 2002.
Summary: the maps contain information on potential oil spill sources and distribution of biological resources of international importance in circumpolar areas. The maps do not reflect the biological resources' sensitivity to oil pollution but they can be used as baseline information for risk assessment in oil and gas activities in the Arctic.

Arctic Shoreline Clean-up Assessment Technique (SCAT) Manual, 2004
Summary: In many countries, the shoreline clean-up assessment technique (SCAT) has been carried out during OSR operations for many years. SCAT teams carry out a systematic study of the area affected by the oil spill to quickly collect information on the shoreline status and degree of oil contamination. The data is then used for making prompt decisions regarding planning and clean-up response. This Manual accords with previous editions and is fully compatible with them. However, this version contains new data on: the unique coastal areas of the Arctic regions; specific features of the various forms of snow and ice cover onshore and in the coastal Arctic zone and other areas that experience cold climates during winter months; data on oil behavior and, SCAT teams activities in similar conditions. In addition, the latest version includes guidelines for rescue teams and a shortened version of the main reporting forms for oil pollution data collection that can be used by the local population at the initial stage of assessment. The guidelines have been translated into Russian.

Guidelines for the Transfer of Refined Oil and Oil Products in Arctic Waters, 2009
Summary: The Guidelines are developed for vessels involved in the supply of oil and oil products to residential areas, industrial enterprises and other vessels in the Arctic areas. The Guidelines specify measures to prevent oil spills during transfer of oil and oil products from one vessel to another or from a vessel to an onshore facility. Appendices to the Guidelines include recommended equipment for containment of oil spills and a checklist of oil transfer operations. The Guidelines have been translated into Russian.

1.3.2.4 Environmental "Hot Spots" in the Russian part of the Barents Sea

One of the observers of AC activities is the Nordic Environment Finance Corporation (NEFCO) established by the Governments of Norway, Finland, Iceland, Denmark and Sweden in 1990. NEFCO deals with environmental protection issues including those in the Barents Sea, and finances projects targeted at its improvement.

Special attention is paid to the environmental "hot spots" in the Russian part of the Barents Sea identified by AMAP on request from NEFCO in 2003. The results were provided in the Report "Update of Environmental 'Hot Spots' List in the Russian Part of the Barents Region: proposals for environmentally important investment projects"[9]. Based on the results of the study, a list of 42 environmental "hot spots' and 57

[8] Inuktitut is one of Inuit dialects in Canada. Inuktitut is spoken all over Northern Canada, in Newfoundland and Labrador, Quebec, Manitoba, Nunavut and earlier – on the Arctic coast of Yukon.
[9] The results of the first stage of the programme were published in 1995 as the NEFCO/AMAP Report "Proposals for Environmentally Important Investment Projects in the Russian Part of the Barents Region".

investment projects targeted at their elimination were made. Among the priority projects related to oil spill prevention and response the following are of note:

Project M9 – Clean-up of the Kola Bay from ship wrecks

In 1980-1990's, due to the dramatic decrease in the number of Navy ships and vessels and the trawling fleet fishing vessels, over 120 vessels and their wrecks were left in the coastal area of Kola Bay. This process was uncontrolled and resulted in a gross violation of existing environmental law.

As part of the UNEP/GEF Project "Russian Federation - Support to the National Action Plan for the Protection of the Marine Environment" the estimation of the degree of impurity of bottom waters and sediment of the southern elbow of the Kola Bay due to the human impact was carried out in 2008, and a technical assignment for the development of the polluted sediments purification project of the Kola Bay was developed (Estimation of the degree of impurity ..., 2008).

Analysis of seabed sediments samples in the locations of the shipwrecks showed an increased concentration of oil products and heavy metals. In addition to the environmental hazards, the shipwrecks pose a threat to navigation in Kola Bay and, consequently, increase risks of accidents that may cause oil spills.

With the NEFCO support a plan has been developed for the lifting and dismantling of the seal-hunting vessel Teriberka, which is lying on the Bay's seabed, within the borders of the Murmansk Sea Port. An agreement is in the process of development, which will establish databases on the negative impact of the shipwrecks on the environment and on the Kola Bay status as well as measures to clean-up the shipwrecks near the Lavna and Tri Ruchya settlements.

The problem of cleaning the coastal area of the Kola Bay from submerged vessels was announced long ago. Resolution of the Administration of the Murmansk region as of 27.10.1997 No. 454 On the measures to clean up marine water areas and shorelines of the Kola Peninsula from abandoned ships and other floating crafts was taked to solve the problem. However, due to lack of financial support, this resolution was implemented only partially.

In 2002 under the assignment of the Ministry of Natural Resources of Russia in the framework of the 'Identification and examination of facilities (landfills), ships and metal structures and creation of dismantling database' programme measures were organized to identify and examine the metal scrap facilities (landfills) in the coastal area of the Kola Bay. Limited funding for work under the programme allowed obtaining only an overview of the landfills in the Kola Bay and perform inventory, monitoring of sediment and underwater inspection of only two of nine large landfills.

By Resolution of the Government of the Murmansk region as of 09.12.2005 No. 488-PP 'On the regional targeted programme Safety and Environmental Hygiene and Ecological Safety in the Murmansk region for 2006-2008' the development of 'Environmental Safety of the Kola Bay' programme was provided for with one of the purposes to clean the Kola Bay of abandoned or sunken ships. However, this programme has not been implemented as well.

The cleaning of the Kola Bay of abandoned ships is maintained by organizations that have licenses for the procurement and processing of ferrous and nonferrous metals. However, due to lack of funds the work is being carried out slowly.

According to Federal State Institution Administration of the Murmansk Sea Port (FSI AMSP) operations to lift Teriberka vessel hav been carried out by the Federal State Unitary Enterprise MBASU according to the previously developed vessel recovery plan. As a result of such lifting operations during the period from June 1, 2009 to May 15, 2010 it became obvious that it is impossible to implement the work according to the developed plan. On June 29, 2010 FSUE MBASU sent a conclusion on the Teriberka vessel work results to the FSI AMSP where it stated that “the hull compartments of the wreck can not be drained with compressed air up to a limit of lifting weight, taking into account the suction force of the vessel to ground due to multiple breaks and fractures of steel topside plates and decks - lifting of the vessel is not possible.

It is possible to dismantle the hull of Teriberka on-site:
- Using electric arc cutting, at a total cost of 60 840 thousand rubles;
- Using underwater hydraulic rope saw, at a total cost of works 50-55 000 thousand rubles.

These works can be implemented provided the funding is made.

Project M10 – Solution to the problem of oily waste treatment in Murmansk Region

Currently, the Murmansk Region has no facilities for the treatment of large quantities of oily waste. Some waste is delivered to boiler houses and some is burnt at the source enterprises in furnaces and boilers. The technologies and equipment used for oily water treatment are out of date and do meet the treatment quality as per regulations. Solid oily waste handling is an acute problem: slug from heavy oil tanks, oily soil and sand, oily cloth etc. The large quantity of fuel needed for complete thermal decontamination of the waste and the high price of the equipment are serious obstacles to the solution of the problem. Some solid oily waste is delivered to domestic or industrial waste landfills.

Within the time frames of the long-term target program “Waste in 2009-2013” developed by the Murmansk Region Committee of Nature Management and Environment, the intention was to draft, by the end of 2010, the “Declaration of Intent to Invest into Construction of Industrial Facility for Decontamination, Utilization and Disposal of Waste Containing Oil and Oil Products” that would have become the foundation for the development of the design documentation for the facility in 2011. However, due to a funding reduction in the budget, the work has been suspended.

1.3.3 Cooperation of the Arctic Countries in improvement of OSR technologies

As was shown in sub-section 1.2.2, oil spill response in the Arctic during winter months is complicated by low temperatures, limited visibility during the Polar Night in the High North, difficult ice conditions etc. The OSR methods traditionally used at sea, at middle and low latitudes, may not always be as efficient as in the Polar seas. For this reason, one of the priorities in cooperation between the Arctic states, is the adaptation of existing OSR technologies and equipment to suit Arctic conditions and research into new technical solutions applicable to this area.

The areas of interest and main results of the international projects “The Joint Industry Program on Oil Spill Contingency for Arctic and Ice-Covered Waters [JIP on Oil in Ice] and “Oil Spill Response 2010” are described below.

JIP on Oil in Ice

“The Joint Industry Program on Oil Spill Contingency for Arctic and Ice-Covered Waters” (JIP on Oil in Ice) was implemented in 2006 – 2009 with the support of oil companies, Norwegian Coastal Administration, NOFO, Coast Guard Department of Sweden and research institutes of USA and Norway. The project was targeted with testing existing OSR technologies, determining their capacities and limitations, proposals for new technical solutions and, identification of areas for further improvement in OSR methods.

a)

b)

Fig.1.5. Field and laboratory experiments to study oil behavior under ice conditions and test OSR technologies: a – testing of oil burning technology at SINTEF field station (Svea Field station), Svalbard Archipelago; b – study of oil behavior under ice conditions at the Ice Laboratory (SINTEF Sealab)

The study confirmed that, as the oil is weathered[10], certain OSR technologies may become less efficient. For example, the possibility for oil ingnition and burning decreases as it spreads on water and the oil slick becomes thinner. In cold water with ice present (if the ice concentration is between 70-90%) oil slick drifting and weathering slows down allowing several additional days in which to consider the response.

Testing of various types of skimmers showed that mechanical recovery under ice conditions is possible, in particular, in the openings between blocks of ice. Based on the study results, two new types of skimmers were designed and successfully tested as well as a system for spot dispersal spraying that allows the use of dispersants with ice concentration up to 80-90%.

Fig.1.6. Oil burning technology testing, 2009

[10] After release on the water surface under the influence of the sun, wind, and water oil undergoes numerous physical and chemical transformations which are collectively referred to as “weathering”. The weathering process includes evaporation, emulsification, dispersal, dissolution, acidification, sedimentation etc.

One of the main conclusions of the project is confirmation of high efficiency (over 90%) of dispersants and oil burning technologies under ice conditions (Sørstrøm, 2010). This conclusion is especially important for OSR operations planning. When the access to the oil spill location and availability of mechanical recovery is very limited, in-situ burning and dispersants may be the only possible solutions. Earlier SINTEF publications (Daling, 2001) showed that modern dispersants are far less toxic and safer for the environment than the substances used 20-30 years ago allowing for further potential development of this technology.

During the course of laboratory and field testing, a substantial amount of information has been gathered with regards to oil behavior under ice conditions, efficiency of various OSR technologies at different stages of oil weathering, oil drift under ice conditions etc. The accumulated experience and test results will act as the foundation for further improvement of response methods and actions for OSR in ice conditions.

Oil spill response 2010

The project “Oil spill response 2010” was initiated by NOFO with support from the Norwegian Coastal Administration and targeted improvement and development of new OSR technologies. The project’s objective is the financing of Research and Development (RD) in the areas of oil spill monitoring and OSR onshore and in coastal and open waters; the development of dispersant technologies is covered under a separate section. Over 170 applications from 120 Norwegian and international companies have received for funding for various ideas.

1.3.4 Clean-up of Artic Sea Water from Oil Contamination

As the world practice shows, usually maximum 10-15% of oil spilt in the Artic can be recovered. Oil that has reached the shore can be accumulated in cracks and hollows between rocks, and by penetrating outwards become a source of long-lasting contamination of the coastal water environment. In the areas with low water exchange the water area can be covered with oil slick for a long time.

During the period from 2007 till 2009 with the support of the UNEP/GEF project ”Russian Federation - Support to the National Programme of Action for the Protection of the Arctic Marine Environment (NPA-Arctic)” the team of experts in marine biology, biotechnology, hydrology, engineering and ecology, joined under OOO SIRENA implemented the pilot project “Cleaning of Arctic Marine Pollutions” which showed new technologies in clean-up of sea water from oil slicks (The Pilot Project Report…, 2009). The project included testing of plantation – a biofilter, based on a symbiotic association: brown algae and hydrocarbon oxidizing bacteria. (Fig. 1.7).

a) *б)*

Fig.1.7. Installation of ropes with algae on the plantation: a - installation of ropes with interlaced fucus algae; b – plantation-biofilter in the Olenya Bay (April 2008). The gullet of the Bay is a harbour for Navy vessels – one of the sources of contamination.

The Olenya Bay (the Barents Sea) with potential contamination sources: Submarine Dismantling Yard Nerpa and Navy ships with a harbour in the seaward part of the Bay was selected as a testing site. During the test period there were several man-made discharges of petroleum products into the Olenya Bay. The algae on the plantation were in close contact with the oil slick for a long time, functioning as booms and cleaning-up the water surface. The estimates of oil degradation with the help of algae based on the test on the plantation and simulation experiments showed that 1 ha of plantation – biofilter can neutralize approximately 100 kg of petroleum products during one week.

The results of the pilot project showed a capacity of fucus algae to accumulate and neutralize petroleum products, thus contributing to self-cleaning of Arctic water basins.

1.4 CONCLUSIONS

International experience has shown that, after response to a large oil spill, the affected countries identified a need to revise and improve both the systems of oil spill prevention and response at the national level and the mechanisms for international cooperation. For example, after the incident with the tanker Erika in 1999, IMO adopted new standards for oil tankers and after the incident with the dry-cargo vessel Baltic Carrier in 2001, the Committee responsible for monitoring of implementation of the Helsinki Convention (HELCOM) revised the adopted OSR methods for the Baltic Sea. The European Maritime Safety Agency (EMSA) was also created to contribute to the enhancement of the overall maritime safety system in the European Community. In general terms, EMSA provides technical and scientific advice to the European Commission in the field of maritime safety and prevention of pollution by ships in the continuous process of updating and developing new legislation, monitoring its implementation and evaluating the effectiveness of the measures in place. EMSA has established and funds a network of at-sea oil recovery services from vessels based in all the regional seas of Europe. EMSA currently maintains contracts for fifteen fully equipped oil recovery vessels (ORV), which are available, upon request, to assist coastal states in oil spill operations. The latest vessel to enter service is based is an ice breaker based in the Baltic Sea.

However, in spite of the gradual tightening of sea safety regulations and environmental protection requirements, the reasons for accidents are: human factor, technical malfunctions, extreme weather conditions and, finally, neglecting the established rules. The recent incident, that took place in the Gulf of Mexico in 2010 is a poignant reminder that even the highest standards and cutting-edge technologies cannot guarantee prevention and a quick oil spill response, even in southern waters.

Large oil spills, around the globe, have demonstrated the importance of joint efforts and international support, especially in the Arctic where the combination of harsh natural conditions, long distances and a large number of areas with difficult access and sparse population make the tasks for response teams challenging and sometimes even impossible.

The cooperation of the Arctic countries in oil spill prevention and response is based on agreements and memorandums of understanding whereby the Arctic countries may ask each other for assistance if their own resources are insufficient for oil spill combating. However, for an efficient response, mobilizing all the available resources may not be enough. In spite of the similarities in OSR methods used throughout the world, individual countries have a preference for different response options. In addition to this, different authorities may be responsible for oil spill combat in different countries, including private companies with specific responsibilities for their area of operation. And finally, in case of joint actions by two or more countries, communication problems may arise due to OSR personnel not being able to communicate in a common language. To develop systems of interaction and increase emergency preparedness, the agreements' member states arrange annual international OSR exercises, develop plans of joint actions, test equipment, involve new participants in the work etc.

Apart from joint OSR exercises and experience exchange, a promising field for further improvement of response system is the improvement in the implementation of OSR technologies applicable for the Arctic and especially ice conditions. In-situ burning and dispersants use are effective OSR options in remote areas and complex ice conditions when the use of mechanical equipment is limited or even impossible and should be given further consideration.

Taking into consideration underdeveloped or unavailable infrastructure in most of the Arctic areas, construction of storage facilities for modern OSR equipment is required to minimize the time taken for delivery of equipment to the spill site. In addition, OSR operations may be compromised through labour shortage during clean-up of the shore; which is why training the local population in OSR is an important prevention measure.

To improve the OSR system in the Barents Sea and generally in the Arctic, the countries should continue their cooperation of joint exercises and knowledge sharing to address the existing challenges in this area.

2 ANALYSIS OF THE EXISTING OIL & PETROLEUM PRODUCTS SPILL RESPONSE SYSTEM IN THE ARCTIC ZONE OF THE RUSSIAN FEDERATION, DEVELOPMENT OF THE TOP PRIORITY ACTIONS FOR ITS IMPROVEMENT

Under the conditions of oil and gas development on the Arctic coastal shelf, the improvement of national oil spill response systems (OSR systems) becomes a topical matter in the Arctic countries, including improvement of national legislation and their standardizing in accordance with uniform norms and regulations in order to provide for smooth coordination of the Arctic countries in oil spill prevention and response.

The Arctic countries practice a good deal of common approach to combating oil spills at the national level. Their conceptual framework and term base are very close. More or less all Arctic countries apply similar methods for oil spill detection and prevention, as well as risk assessment linked to oil spills. National oil spill response systems possess in general a similar organizational structure, comprising the following basic elements (figure 2.1)

- The legislative base, consisting of regulatory documents establishing the system operational procedures and system elements interaction;
- Scientific methodological support including well-grounded methodological complex and recommendations for pollution prognosis and prevention, oil spill clean-up operations and response of oil spill effects;
- The resource base, including complex of resources for oil and petroleum product spill prevention and response actions. Normally the resource base comprises material resources (special technical facilities and equipment, communication means, etc) manpower (qualified personnel, managers, facility operators, labour force), financial resources (reserves, insurance funds), information resources (reference and operational information, data acquisition and transmission system, etc).

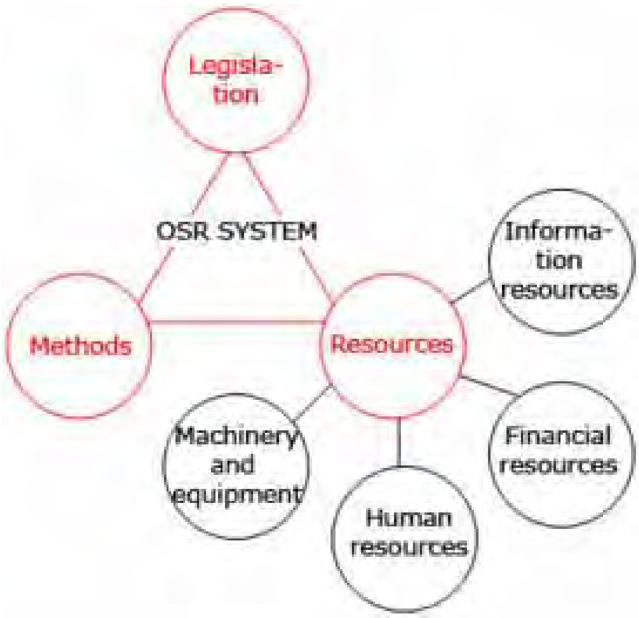


Figure. 2.1. Sample of a national OSR system organizational structure

Normally all existing national OSR systems split in state and commercial tiers, each bearing respective civil liability.

Generally all national OSR systems are based on principles as follows:

- Potential polluters are obliged to develop the contingency plan for oil and petroleum product spill response actions and at its own discretion provide for respective level of oil spill preparedness;
- The polluter bears financial liability;
- The polluter is obliged to notify the authorities on oil spill and report to the authorities and mass media;
- Organizations and departments are obliged to render support in case of oil and petroleum product spill;
- The competitive national body bears responsibility for organization and stabilization of the country oil spill preparedness, as well as action coordination of state and commercial bodies in the national oil spill response system.

General analysis of the Russian oil and petroleum product spill response system and analysis pertaining to peculiarities of the Arctic region has been carried out within the frames of the present report: as well as analysis of the Russian legislation in the field of OSR, review of international cooperation legal framework between the RF and the other Arctic countries in the field of oil spill prevention and response, directions of top priority actions have been suggested for improvement of the Russian OSR system.

2.1 National Oil and Petroleum Product Spill Response System in the Russian Federation

2.1.1 The Organizational Structure of the Uniform State System (RS ES) and the OSR Functional Subsystem within the Framework of RS ES

In accordance with the Russian legislation oil and petroleum product spills are classified as Emergency Situations (ES). Therefore, organization of oil and petroleum product spill prevention and response operations is carried out within the frameworks of the Uniform State System for Prevention and Response to Emergency Situations.

Functional and regional Emergency Situation Prevention and Response subsystems are established within the framework of RS ES. Functional subsystems are established by federal executive authorities (FEAB) and authorized organizations in compliance with their state functions. The regional subsystems are established in the subjects of the RF within territorial limits and comprise units relevant to administrative-territorial division of the areas (Government Resolution(GR) of the RF No. 794 of 30.12.2003 г.).

The functional subsystem for prevention and response to offshore oil and petroleum product spills emerged from vessels or facilities regardless their ownership or nationality (OSR functional subsystem) is established by the Ministry of Transport of the RF (Mintrans of Russia) within the framework of RS ES. The Mintrans of Russia via the Federal Agency of Sea and River Transport (Rosmorrechflot) and its regional divisions bears responsibility for organization of operations for oil and petroleum product spill prevention and response at sea. The Mintrans of Russia and Rosmorrechflot are competent national bodies responsible for oil spill response preparedness in compliance with the requirements of the International Convention OPRC-90 (GR of RF No. 794 of 30.12.2003, GR of RF No. 607 of 23.07.2009, GR of RF No. 53 of 06.04.2009).

The functional OSR at sea subsystem acts on federal, regional and facility tiers within the framework of RS ES. Hereinafter “the regional tier” means “within the territorial limits of the subject of the RF”, while “the facility tier”’ means “within the boundaries of organizations dealing with oil and petroleum product extraction, transportation, refinery and storage”.

The OSR functional subsystem activity targets are prevention (risk mitigation) of ES, caused by potential oil and petroleum product spills at sea from vessels and facilities regardless their ownership or nationality and efficient deployment of forces and resources during containment and response to oil and petroleum product spills at sea.

To achieve the targets as mentioned above the OSR functional subsystem carries out certain operational actions, namely:

- Contingency planning and organization of measures for prevention and response to oil spill at sea from vessels and facilities regardless their ownership or nationality;
- Development and implementation of the contingency plan for prevention and response of oil and petroleum product spills at sea (OSR plan) at the federal tier, regional (basin) OSR plans, seaport administration OSR plans;
- Finalizing and approval as per the set procedure of OSR plans by organizations irrespective of ownership or nationality, dealing with oilfield exploration, oil extraction, transportation and storage offshore;
- Organization of training of Marine Search & Rescue Services, Search & Rescue Units (SRU) and rescue officers in OSR actions;
- Qualification evaluation of marine SRU as per the set procedure;
- Control of preparedness of forces and resources of SRU and their deployment planning;
- Planning and control of disposition-oriented interaction between SRU and other federal bodies;
- Control over OSR facilities and preparedness of SRU reporting to Rosmorrechflot;
- Improvement and development of the functional subsystem, fitting it out with modern special purpose vessels and technical means;
- Methodological support to organizations in marine environment protection and their conformity with national legislation and international agreements requirements in this sphere;
- Execution of bilateral and multilateral international agreements on cooperation in combating sea pollution caused by oil and petroleum product spills at sea
- Participation in development of regulatory and legal framework for oil spill prevention and response at sea;
- Monitoring environment pollution at marine transport facilities and commercial facilities regardless their ownership and nationality, at organizations dealing with oilfield exploration, oil extraction as well as refinery, transportation and storage offshore ;
- Detection of storm protective shelters for oil carriers being in distress at sea.

2.1.2 Managerial Bodies, Forces and Resources of RS ES and the OSR Functional Subsystem

RS ES system unites managerial bodies, forces and resources of the functional subsystems, federal executive authorities, executive authorities of the subjects of the RF, local self-government bodies and organizations, empowered to decide on matters of population and territories protection from ES, including oil and petroleum product spills (GR РФ No. 794 of 30.12.2003).

The activity of the OSR functional subsystem within the frameworks of RS ES is based on interaction of the managerial bodies and organizations reporting to Rosmorrechflot with organizations regardless their ownership or nationality, dealing with oilfield exploration, oil extraction, as well as oil and petroleum products refinery, transportation and storage offshore, and other organizations empowered to decide on matters linked to oil spill prevention and response at sea.

RS ES is controlled by the Government of the RF. EMERCOM of Russia is responsible for organizational and methodological administration and contingency planning within the framework of RS ES. Rosmorrechflot carries out general administration of the functional subsystem. The Federal Transport Control Service (hereinafter referred to as Rostransnadzor) is responsible for control over law compliance in the field of OSR at sea and preparedness for deployment of forces and resources by the functional subsystem.

The following managerial bodies and forces to be established at each RS ES and OSR functional subsystem tier:

- Coordination bodies;
- Perpetual managerial bodies;
- Day-to-day control bodies;
- Forces and resources;
- Reserves of financial and material resources;
- Communication, public address and information support systems

The OSR functional subsystem managerial bodies at the federal tier are shown in table 2.1

Table 2.1.OSR functional subsystem managerial bodies at the federal tier

Managerial Body	RS ES	OSR functional subsystem at sea
Coordination body	Governmental Commission on Prevention and Response to ES and Fire Safety Provision, commissions on prevention and response to ES and fire safety provision (hereinafter CES & FSP)	Rosmorrechflot CES

Managerial Body	RS ES	OSR functional subsystem at sea
Perpetual managerial body	EMERCOM of Russia	Rosmorrechflot
Day-today control body	National Centre of Operation Control in Emergency Situations (NCCES), Centres of Operation Control in ES (CCES), Information Centres (IC)	FSE State Marine Rescue Service of Russia and the State Marine Rescue Coordination Centre (SMRCC)

The OSR functional subsystem managerial bodies at the regional tier are shown in table 2.2

Table 2.2.OSR functional subsystem managerial bodies at the regional tier

Managerial Body	RS ES	OSR functional subsystem at sea
Coordination body	CES & FSP of the executive body of the subject of the RF	Rosmorrechflot CES
Perpetual managerial body	Regional bodies of EMERCOM of Russia in the subjects of the RF (Head Departments of EMERCOM of Russia)	Salvage Departments (BASU) and Subsea Emergency Rescue Departments (SERD)
Day-to-day control body	CCES of Head Departments of EMERCOM of Russia in the subjects of the RF, IC, Duty operation control services (DOCS) of executive bodies in the subjects of RF and regional bodies FEAB	Marine Rescue Coordination Centres (MRCC), Marine Rescue Subcentres (MRSC) and duty control services of BASU and SERD

The OSR functional subsystem managerial bodies at the object tier are shown in table 2.3

Table 2.3.OSR functional subsystem managerial bodies at the facility tier

Managerial Body	RS ES	OSR functional subsystem at sea
Coordination body	CES of organizations regardless their ownership and nationality, dealing with oil field exploration, oil extraction, as wells as oil refinery, transportation and storage offshore	CES of organizations reporting to Rosmorrechflot, CES of organizations regardless their ownership and nationality, dealing with oil field exploration, oil extraction, as wells as oil refinery, transportation and storage offshore

Perpetual managerial body	Organizational subdivisions, empowered to decide on matters linked to population and territories protection from ES	Seaport administrations located in the seaport responsibility area, FSUE Rosmorport and its subsidiaries at the objects
Day-to-day control body	Duty operation control services of organizations, dealing with oilfield exploration, oil extraction, as well as oil refinery, transportation, and storage offshore	Duty operation control services of marine transport organizations, seaports, subsidiaries of FSUE Rosmorport, shipping companies and other organizations regardless their ownership or nationality, dealing with oilfield exploration, oil extraction, as well as refinery, transportation and storage offshore

2.1.3 Forces and Resources of RS ES and the OSR Functional Subsystem at Sea within the Framework of RS ES and their Mobilization Procedure

Specially trained forces and resources of FEAB, RF subject executive authorities, local self-government bodies, commercial and public organizations, entitled and engaged in prevention and elimination of ES are classified as forces and resources of RS ES. Forces and resources at each tier of RS ES comprise forces and resources of instant readiness, aimed at operational emergency response and elimination operations (instant readiness forces) (GR of RF No. 794 of 30.12.2003).

The basis of the instant readiness forces of the OSR functional subsystem at sea is comprised of marine professional SRU: FSUE Murmansk Salvage Department (MBASU), FSUE Baltic Salvage Department (Baltic BASU), FSUE Sakhalin Salvage Department (Sakhalin BASU), FSUE Far East Salvage Department (Far East BASU), FSUE Novorosiisk Marine Subsea and Emergency Rescue Department, FSUE North-Caspian Marine Subsea and Emergency Rescue Department, their subsidiaries, as well as MRCC and MRSC.

Forces and resources of OSR functional subsystem at sea are comprised of multi-purpose, rescue and special purpose vessels, motor and floating facilities owned by BASU and SERD and their subsidiaries, and intended for operations during OSR; marine special units (hereinafter MSU), manned with the personnel specially trained and qualified as per set procedure, and equipped with OSR technical facilities at sea; as well as forces and resources of subordinate or contracted Navy Salvage & Rescue Units, organizations regardless their ownership or nationality, dealing with oilfield exploration, oil extraction, as well as oil refinery, transportation and storage offshore, engaged in OSR operational actions in accordance with OSR contingency plan at sea.

To provide for operational oil spill response offshore a 24-hour duty by OSR forces and resources is organized in BASU, SERD and seaports. In the area of responsibility of each BASU, SERD a multi-purpose rescue boat or a rescue towboat is laid on duty, with OSR facilities onboard, a Marine Special Unit equipped with respective OSR facilities, auxiliary and floating craft.

Deployment of forces and resources of the OSR functional subsystem at sea is carried out in accordance with special OSR contingency plan, namely:

- Federal contingency plan for oil and petroleum product spills of federal tier, which provides for potential transportation of OSR resources from one basin (sea area) to another, as well as engagement of international resources;
- Regional contingency plans for oil and petroleum product spills of regional tier, which provide for potential deployment of OSR resources of respective area (basin), whose basis is comprised of forces and resources of respective local BASU and SERD;
- Contingency plans by seaport administration for oil and petroleum product spills in the areas of responsibility of respective seaport administrations;
- OSR organizations contingency plans for oil and petroleum products spills at facilities of organizations regardless their ownership or nationality, dealing with oilfield exploration, oil extraction, as well as oil and petroleum products refinery, transportation and storage offshore (order of Mintrans of the RF No. 53 of 06.04.2009).

FSD State Marine Salvage and Rescue Administration of the Russian Federation (SMSRA of Russia) organizes and controls forces and resources preparedness of BASU and SERD and level of salvage and rescue readiness to OSR offshore, qualifies the readiness level, organizes and controls OSR operational actions at sea from vessels and objects regardless their ownership or nationality by forces and resources of BASU and SERD (Order of Mintrans of the RF No. 53 of 06.04.2009).

ENERCOM of Russia coordinates operational actions of salvage & rescue services and salvage & rescue units on the territory of the RF. Head Departments of Emercom of Russia coordinate operational actions of salvage & rescue services and salvage & rescue units on the territory of subjects of the RF (GD of the RF No. 794 of 30.12.2003).

2.1.4 Reserves of Financial and Material Resources

In compliance with the Russian legislation operation of RS ES and ES prevention and elimination actions are financed by respective budget funds and property owners (users) (GR of the RF No. 794 of 30.12.2003).

Organizations dealing with oilfield exploration, oil extraction, as well as oil refinery, transportation and storage offshore are obliged to allocate financial reserves and material and technical resources for oil spill containment and response (GR of the RF No. 240 of 15.04.2002).

Organizations regardless their forms of property shall participate in ES elimination at their own discretion (GR of the RF No. 794 of 30.12.2003).

Allocation of funds for financing ES elimination operational actions from the Reserve Fund of the Government of the RF for prevention and elimination of emergency situations and consequences of natural disasters is carried out as per the procedure set by the Government of the RF (GR of the RF No. 794 of 30.12.2003).

For the purpose of operative elimination of ES effects EMERCOM of Russia has the right to apply as per the set procedure the appropriate financial reserve for prevention and elimination of emergency situation consequences at industrial enterprises, construction sites and transport (GR РФ No. 794 от 30.12.2003).

2.1.5 Communication, Public Address and Information Support System

In compliance with the Russian legislation the federal state authorities, state authorities of the subjects of the RF, local self-government bodies and organizations managerial bodies are obliged to promptly and reliably notify the population via mass media, including special technical communication means for public address and announcement in crowded areas, as well as other communication channels, on the status of population and territories protection from emergency situations and operational actions taken for safety provision, on predicted and emerged ES, on methods and means for population protection against it.

The information support to the OSR functional subsystem at sea is provided by SMRCC FSI State Marine Rescue Service of Russia, MRCC and MRSC. Receipt of notifications on oil and petroleum product spills at sea, vessel communication with MRCC and MRSC, operation control headquarters at OSR at sea, as well as transition of information on navigation safety onboard vessels is provided by the global marine safety communication system in sea disaster.

Organizations dealing with oilfield exploration, oil extraction, as well as oil refinery, transportation and storage offshore are obliged to promptly notify the respective state authorities and local self-government bodies as per set procedure on oil and petroleum product spills.

Notification on sea pollution with oil and petroleum products shall be made in accordance with the Procedure for data acquisition and exchange in the RF in the field of population and territories protection from ES of natural and technological origin (GR of the RF No. 334 of 24.03.1997), as well as Procedure Specification for transition of notifications on sea environment pollution, approved by the Ministry of Natural Resources of Russia, Ministry of Transport of Russia and the State Committee on Fisheries.

OSR communication and public address schemes, organization of information support at the oil & petroleum product spill site, development of forecast of the oil pollution and expected effects are stipulated in the respective OSR contingency plans.

Mutual notification of responsible services of neighboring states on oil pollution and status of OSR operational actions shall be carried out in compliance with the applicable bilateral and multilateral international agreements of the RF on Cooperation in Combating oil and petroleum products sea pollution.

2.1.6 Operational Modes of Managerial Bodies, Forces and Resources of the OSR Functional Subsystem

In default of ES threat the managerial bodies and forces shall function in the day-to-day operational mode, bearing responsibility for the following actions:

- Monitoring marine commercial traffic, activities linked to oil and petroleum product industry offshore, forecast of oil spill risks at sea;
- Data acquisition, processing and exchange in the field of marine environment protection against oil spills, as well as population and territories protection from ES, linked with oil and petroleum product spills;
- Contingency planning of actions to be taken by managerial bodies, OSR functional subsystem forces and resources at sea, organization of training and activity procurement;
- OSR salvage and rescue preparedness;
- Actions for development, finalizing, approval and correction (revision) of respective contingency plans for oils spill prevention and response at sea;
- Training SRU and rescue officers in oil spill response and prevention at sea;
- Interaction with SRU of other FEAB in matters related to oil spill prevention and response at sea;
- Oil spill response training exercises;
- International cooperation in the field of marine environment protection;
- Participation in the activities of IMO (International Maritime Organization) and international regional organizations;
- Extension of knowledge in population and territories protection from oil and petroleum product spills;
- Control over establishment, deployment, storage and replenishment of material resources reserves for OSR at sea;
- Development and implementation of target and scientific-technical programmes and actions for OSR at sea;
- Statistics reporting on operational actions in OSR, participation in investigation of incidents and disasters at sea, linked to oil and petroleum product spills, as well as development of a contingency plan for elimination of reasons for such incidents and disasters.

Besides the day-to-day operational mode of managerial and OSR functional subsystem bodies the following operational modes can apply:

1) High alert mode – at ES hazard;
2) Emergency situation mode – at ES initiation and response.

In the high alert mode the OSR functional subsystem and managerial bodies shall carry out the following actions:

- Improvement of control over marine commercial traffic, activities linked to oil and petroleum product industry offshore, forecast of oil and petroleum product spill risks at sea and their consequences;

- Introduction of 24 hour duty for top managers and responsible personnel of the managerial and functional subsystem bodies at stationary command posts;
- Continuous acquisition, processing and transmission of data to managerial bodies, the functional subsystem resources, engaged executive authorities and organizations, on oil and petroleum product spill forecast at sea;
- Operational actions for oil and petroleum product spill prevention and preparedness at sea, mitigation of potential damage should it occur, as well as improvement of stability and operation safety of respective organizations at oil and petroleum product spills
- Update of respective contingency plans for oil spill response and prevention at sea;
- Mobilization of forces and resources of the functional subsystem to readiness mode for oil and petroleum product spill response at sea, formation of operational teams and their deployment to anticipated activity areas;
- Replenishment of material reserves, allocated for OSR at sea;
- Evacuation operations.

In the mode of initiation and response of emergency oil spill (in the ES mode) the managerial and functional subsystem bodies shall carry out the following actions:

- Notification of FEAB, RF subject executive bodies, local self-government bodies, organizations senior executives, as well as population on oil and petroleum product spill at sea;
- Organization of 24-hour duty by senior management and responsible personnel of managerial bodies and personnel of the functional subsystem;
- Continuous monitoring of the marine commercial traffic and activity linked with oil and petroleum product industry offshore on the ES site;
- Forecast of oil and petroleum product spill pollution escalation at sea and their effects;
- Operational actions for containment and oil spill response at sea, provision of all-round actions by forces and resources of the functional subsystem;
- Augmentation of forces and resources for OSR should it be necessary;
- Operational actions for protection of the most sensitive marine areas;
- Continuous acquisition, analysis and exchange of data on situation on the oil spill site and response action progress;
- Preparatory actions and appeal to neighboring states for assistance should it prove necessary within the frames of bilateral and multilateral international agreements of the RF in the field of maritime environment protection;
- Continuous interaction with engaged executive authorities and organizations on matters linked to OSR at sea;
- Operations actions for personnel life support during OSR.

During OSR in ES mode operation management headquarters (hereinafter OMH) are established at each tier of the functional subsystem, namely:

- At the federal tier – the federal OMH;
- At the regional tier – the regional OMH;
- At the object tier – OMH of marine commercial transport organizations regardless their ownership or nationality dealing with oilfield exploration, oil extraction as well as oil refinery, transportation and storage offshore.

The organizational structure of RS ES presenting the OSR functional subsystem at sea and regional system of RS ES of the Murmansk region is shown in the diagram (figure 2.2)

2.2 Analysis of the OSR Legislation in the Russian Federation

“the efficient domestic legislation on environment is the necessary condition for environment protection”
(The Nuuk Declaration on Environment and Development in the Arctic)

2.2.1 List of Basic Legislative Documents in OSR

Approximately 50 legislative documents can be applied to operational actions for oil spill prevention and response in the RF, the documents enlisted below are the basic:

- RF Federal Law of December 21, 1994 No. 68-FZ «On Protection of Population and Territories from Natural and Man-Made Emergencies” (revision of the Federal Law of 19.05.2010 N 91-FZ);
- RF Federal Law of August 22,1995 No.151-FZ «On Emergency Rescue Services and Rescuer Status»
- RF Government Decree of 30.12.2003 No. 794 «On Uniform State System for Prevention and Response to Emergency Situations»;
- RF Government Resolution of August 21, 2000 No. 613 «On Immediate Actions on Oil Spill Prevention and Response»;
- RF Government Resolution of April 15, 2002 No. 240 «On the Procedure for Oil Spill Prevention and Response Activities Organization on the Territory of the Russian Federation»;
- RF Government Resolution of July 23, 2009 No. 607 «On RF Accession to the International Convention on Oil Pollution Preparedness, Response and Cooperation 1990»;
- Order by EMERCOM of Russia of December 28, 2004 No 621 “On Approval of Regulations for Development and Finalization of plans on oil and petroleum product spills prevention and response on the territory of the RF»;
- Order by the Ministry of Transport of the RF of April 6, 2009 г. No. 53 «On Approval of Regulations of a Functional Subsystem for Operational Actions on Prevention and Response to Oil Spill at Sea from Vessels or Facilities regardless their Ownership or Nationality»;
- Order by the Ministry of Natural resources of March 3, 2003 No. 156 « On Approval of Instructions for Determination of the Minimum Oil Spill Level to be Classified Emergency Situation».

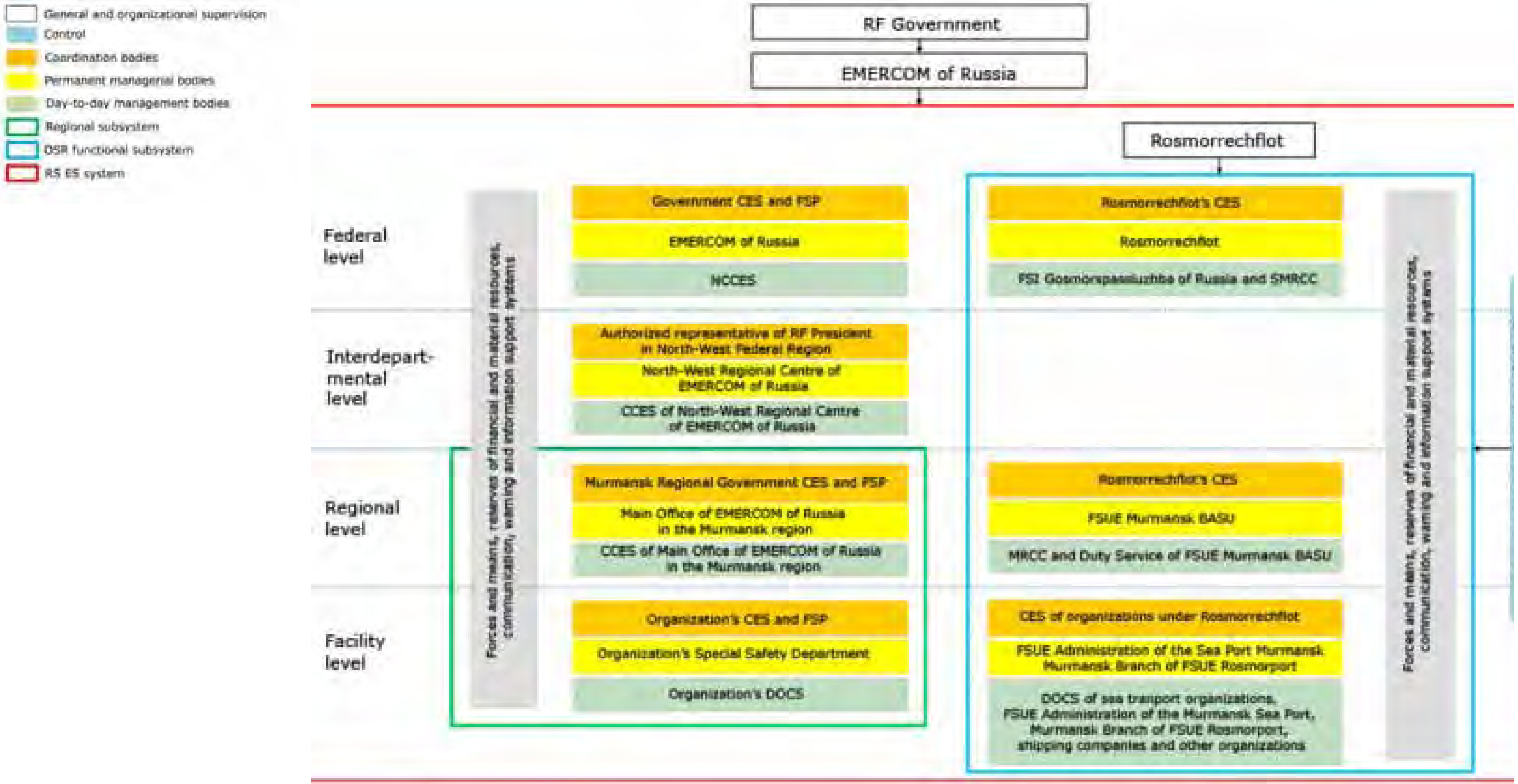


Figure. 2.2 RS ES Organizational Structure applicable to OSR functional subsystem at sea and RS ES territoria system of the Murmansk region

Federal Law No.68-FZ

Federal Law No.68-FZ determines general organizational and legal norms in the RF for protection of population and territories from natural and production induced emergencies and regulates principles and general procedure of ES elimination in the RF. In compliance with this Law the Uniform State System for prevention and response to emergency situations is established in Russia (RS ES), which unites managerial bodies, forces and resources of federal executive authorities, RF subject executive bodies, local self-government bodies, organizations empowered to decide on matters of protection of population and territories from ES.

Federal Law No.151-FZ

Federal Law No. 151-FZ determines general organizational and legal and economic activity basis for all salvage and rescue services and salvage and rescue units (SRS and SRU) including SRU on the territory of the RF, contains provisions on qualification certification of SRS and SRU for ES response, stipulates basic activity principles of SRU, SRS and rescue officers.

Government Resolution No. 794-PP-RF

Government Resolution No. 794-PP-RF approves the Regulation on the Uniform System establishment and operation procedure (RS ES), where the state function for organization of operational actions for OS prevention and response at sea occurred from vessels and facilities regardless their ownership or nationality is imposed on the federal Agency of Sea and River Transport (Rosmorrechflot) and organizations subordinate to Rosmorrechflot: FSI Gosmorspassluzhba of Russia, FSI Seaport Administrations, FSUE BASU, FSUE SERD.

Government Resolution No.607-PP-RF

Government Resolution No. 607-PP-RF governs accession to the International Convention OPRC; the Ministry of Transport of Russia and Rosmorrechflot are assigned competent national bodies, responsible for preparedness and response in case of oil spill pollution. In accordance with the Resolution operation of the national oil spill preparedness and response system as prescribed by the Convention shall be organized within the frames of the functional subsystem for operational actions on oil spill prevention and response at sea occurred from vessels and facilities regardless their ownership or nationality, included into the Uniform System (RS ES). The Area of responsibility of the national preparedness and response system in case of oil pollution covers the inland sea waters, territorial waters and the exclusive economic zone of the RF.

Government Resolutions No. 613-PP-RF and No. 240-PP-RF

Government Resolution No. 613-PP-RF stipulates the basic requirements to development of contingency plans, being the basis to operational actions on oil spill prevention and response. Government Resolution No. 240-PP-RF makes amendments to Government Resolution No. 613-PP-RF, as well as stipulates Standards for actions on oil spill prevention and response.

Order by EMERCOM of Russia No. 621

Order of EMERCOM of Russia No. 621 stipulates Standards for development and finalizing contingency plans for oil spill prevention and response on the territory of the RF.

Order by the Ministry of Natural Resources of Russia No. 156

Order of the Ministry of Natural Resources of Russia No. 156 classifies the oil or petroleum product spill in the quantity of 0,5 tons and higher in the seas of the Arctic Ocean as an Emergency Situation.

Order by the Ministry of Transport of Russia No. 53

Order of the Mintrans of Russia No. 53 stipulates Regulations on the functional subsystem for oil spill prevention and response at sea occurred from vessels and facilities regardless their ownership or nationality, which determine the organization, forces and resources of the OSR functional subsystem at sea, as well as its operation procedure.

2.2.2. Basic legal requirements to organizations dealing with oilfield exploration, oil extraction, as well as refinery, transportation and storage of oil and petroleum products

In compliance with the Russian legislation all organizations regardless their ownership, dealing with oil and petroleum product extraction, transportation, refinery and storage are obliged to establish a facility oil spill prevention and response system, and are entitled within the framework of this system to the following:

1. Plan oil spill response operational actions for the purpose of determination of the necessary manpower and special technical facilities for containment of the spills within the time period not exceeding 4 hours after receipt of the spill notification.

2. Provide for forecast of oil spill effects and derivative emergency situations on the basis of risk assessment with regard to adverse hydro meteorological conditions, season, daytime, terrain relief, ecology and land and water area utilization pattern in order to determine necessary manpower and special technical facilities for operational actions.

3. Establish own SRU, carry out their qualification evaluation in compliance with the Law of the RF, equip them with special technical facilities or conclude agreements with the Navy SRU, empowered to OSR operational actions and certified as per set legal procedure.

4. To promptly notify the respective authorities as per set procedure on oil and petroleum product spills and organize operational actions for their containment and response.

5. Allocate financial reserves and material resources for OSR and containment.

6. Provide for duly maintenance of the process equipment, timely engineering-technical actions, aimed at prevention of potential oil and petroleum product spills and (or) mitigation of the effect danger.

7. Establish and maintain the oil and petroleum product spill detection systems in duly readiness mode, as well as communication and public address systems.

Planning OSR operational actions, determination of necessary manpower and special technical facilities for OSR operational actions; risk assessment and forecast of oil spill effects shall be carried out by organizations within the framework of OSR facility contingency plans. OSR plans shall contain information on procedure for notification of authorities and deployment of SRU, list of engineering-technical operational actions for potential oil spill prevention and effect mitigation, status of readiness of communication and public address systems, financial and material-technical reserves being at disposal of organizations, as well as other information as stipulated by normative requirements of the RF legislation.

The facility OSR contingency plans must meet respective planning standards. The concept of “the planning standard” provides that at the facility tier. i.e. the organization tier, the plan can be developed from the local to the federal planning tier depending on the maximum potential forecasted oil spill volume at the organization facility (Order by EMERCOM of Russia No. 621 of 28.02.2004). The organization facility OSR system must conform to the planning tier as stipulated by the OSR contingency plan.

The facility OSR offshore contingency plans shall be agreed with the seaport administration, respective FEAB territorial bodies, special maritime inspectorate of the Ministry of Natural Resources of Russia and approved by their senior management and the territorial body of the EMERCOM of Russia in the RF subject.

The facility offshore OSR regional contingency plans shall be agreed with respective FEAB, special maritime inspectorate of the Ministry of Natural Resources of Russia, CES of executive authority bodies of the RF subjects, regional headquarters of the EMERCOM of Russia, respective regional subdivisions of the Ministry of Transport of Russia, approved by its senior management, FEAB in the respective industrial branch, the Mintrans of Russia and the EMERCOM of Russia.

The facility offshore OSR federal contingency plans shall be agreed with CES of EAB of the RF subject, Regional Headquarters of the EMERCOM of Russia, respective regional subdivisions of the Mintrans of Russia and FEAB, and shall be approved by its senior management, FEAB of the respective industrial branch, the Mintrans of Russia and the EMERCOM of Russia.

The facility OSR contingency plans can be put into effect only after agreeing and approval by the respective organizations and executive authority bodies. Should an organization dealing with oil and petroleum product extraction, transportation, refinery and storage offshore fail to have an approved OSR contingency plan, such breach can cause sanctions by control bodies: administrative penalty, forfeiture of license or license prolongation denial, and finally a prohibition on operation with oil and petroleum products offshore.

The facility OSR contingency plan of the regional and federal tiers shall be agreed and approved at 8-9 authority levels. In compliance with the RF Law each body that receives the OSR contingency plan for agreement, has the right to review it within a 30-day period. The deadline for the review duration prior to approval is not stipulated by the Law. Therefore final duration of the agreement and approval procedure of the facility OSR contingency plans of regional and federal tier can reach one year at best provided no remarks are made to the plan content by the agreeing and approval bodies.

Unspecific character of regulatory requirements to the structure and contents of the OSR contingency plans offers the possibility to the agreeing and control bodies to interpret these requirements at their own discretion and often make groundless remarks. Requirements to the structure and contents of the OSR contingency plans suit mostly coastal industrial facilities and do not take into consideration the peculiarities of the planning offshore facilities. Eventually, as the Russian applicable practice shows, the procedure of agreeing and approval of the OSR contingency plans of the regional and federal tier can last for years.

Therefore, drawbacks in certain Russian legal requirements in OSR contingency planning create a number of administrative barriers, which essentially complicate organizations’ execution of legal requirements to establishment of the facility OSR and prevention systems and introduction of respective OSR plan provisions into effect. Bearing in mind that in accordance with the Russian Law (Order of EMERCOM No. 621 of 28.02.2004) the plans of the functional and territorial RS ES subsystems shall be developed on the basis of the organizations' facility OSR contingency plans, the aforesaid drawbacks of the Russian legal provisions cannot but have negative influence on the efficacy of the Russian national OSR system in general.

2.3 Role and Functions of Commercial Emergency Rescue Divisions in the National Oil and Petroleum Product Response System in the Russian Federation

Apart from the state structures also commercial organizations bear responsibility in the RF for OSR preparedness at organizations' facilities; the commercial SRU are certified as per set state legal procedure and fulfill the same requirements as similar state OSR structures.

General organization, legal and economic activities basis for the state and commercial SRU are regulated by the basic general Federal Law No. 151-FZ equally obligatory for all salvage and rescue units and services; the basic obligatory tasks imposed on the SRU in accordance with this Law are as follows:

- Instant readiness of the managerial bodies, forces and resources of SRU for deployment on the ES site and the area of ES elimination;
- Control over the readiness of the facility at service for operational action for ES elimination;
- Elimination of the ES at the facilities at service.

Thus and so, each certified SRU including commercial must in accordance with the applicable Law be in instant preparedness for OSR and commence response actions in case an oil spill occurs at the facilities at service in accordance with the concluded agreements and the facility OSR contingency plans.

In compliance with the Russian Law the SRU forces and resources recruited by organizations as per the facility OSR contingency plans and on commercial basis are classified as forces and resources of the OSR functional subsystem at sea (Order by the Mintrans of the RF No. 53 of 06.04.2009), however in the RF at present certain problems linked to conditions of recruitment and deployment of forces and resources of commercial SRU exist. Principally this is due to the following reasons:

1. Unlike the state companies (FSUE BASU, SERD) receiving partial state financial support, such state support to the commercial SRU is not provided.
2. The procedure of commercial SRU recruitment and expenditure reimbursement during OSR is not legally stipulated.

While participating in OSR operational actions, the SRU bears substantial expenses, including transportation and deployment of manpower and facilities, personnel catering, rescue officers salary etc; as per Federal Law No. 151-FZ a SRU must also grant additional paid vacation and medical service including sick leave payments to rescue officers, injured during operations for emergency situation elimination. Expenditure reimbursement to SRU for ES elimination actions as per Federal Law No. 151-FZ must be effected in accordance with concluded agreement for organizations' services or from fund allocated for the emergency situation response.

However, the practice of commercial contracting for organizations' services generally provides for SRU liability only for maintaining the forces and resources preparedness and as maximum deployment of the forces and resources to the ES site. OSR actions carried out by SRU are normally the subject of additional agreements, whose provisions are negotiated between the parties already during the ES mode. This due to the fact, that prior to commencement of operations, the SRU must be confident that the OSR expenditure is to be reimbursed and the works paid for.

As to reimbursement of SRU expenditure from the funds allocated for ES elimination, the Law does not stipulate the origin of the funds and the procedure for SRU expenditure reimbursement from these funds, as well as the law does not stipulate who will grant the guarantee for SRU expenditure reimbursement in cases when the polluter has no possibility to promptly compensate the expenditure in question and pay for the rescue officers work. Such operation conditions are totally unacceptable to commercial SRU operating with self-sustained budget. Besides the majority of SRUs operating in such conditions cannot fully provide for execution of requirements of Federal Law No. 151-FZ on social benefits to recruited rescue officers.

Thus and so, the service agreements concluded by organizations with commercial SRUs do not guarantee immediate response to oil spill, the Law does not fully regulate the activity of commercial SRUs.

Unavailability of clear system of commercial SRU recruitment in the RF, giving guarantee for prompt reimbursement of their OSR operations expenditure causes other negative consequences, namely does not give possibility to account for commercial SRU forces and resources during OSR contingency planning at the regional and federal tier. Besides, commercial SRU compete with each other and the state-owned organizations at the market for oil spill response services, such competition undermines the concept of tier response and interaction within the framework of the national OSR system.

2.4 Assessment of Efficiency of the Russian Oil Spill Response System within the Frameworks of RS ES

To receive an unbiased and detailed assessment of efficiency of the existing OSR system in the RF, including the Arctic area, the following information sources have been consulted:

1. Analysis of the RS ES system, OSR functional subsystem at sea, basic Russian legal requirements to OSR.
2. Summary of interviews with representatives and specialists of the organizations directly engaged in the OSR system in the Murmansk region.
3. Summary of the questionnaire filled out by participants of the research and practical seminar "OSR: contingency planning, preparedness provision and response. Regulatory requirements and operation practice» organized and held jointly by the State Maritime Academy named after Admiral S.Makarov and the North-West Regional Centre of EMERCOM of Russia and FSI State Marine Pollution Control, Salvage and Rescue Administration of the RF (Gosmorspassluzhba) in April 2010.
4. Printed materials, Internet publications, interviews.

Assessment of efficiency of the Russian OSR system has been carried out based on the following criteria:

- Does the Russian national OSR system meet international principles?
- Does the applicable Russian legislation in the OSR sphere provide for operative oil spill response at the regional and federal tiers?
- Does the applicable Russian legislation in the OSR sphere pay attention to peculiarities of the Russian Arctic zone?

Analysis of the aforesaid information sources gave ground to certain conclusions pertaining to efficiency of the Russian OSR system and its conformity with the international standards.

The majority of the Arctic states adduce dour legal requirements to private companies to provide environmental safety of their activities. However, response preparedness for large oil spills is first and foremost the matter of the state tier; and the basis of the national OSR system is comprised of competent national bodies, responsible for organization and maintaining the state preparedness for oil spills, as well as coordination of the state and commercial organizations in the national OSR system.

The primary responsibility in the RF for safety provision during offshore oil and petroleum product operation activities is imposed by the Law on the organizations dealing with oil field exploration, oil extraction and oil and petroleum product refinery, transportation and storage; the basis of the national oil and petroleum product spill response system in the RF is comprised of the facility tier subsystems.

A legally appointed competent national body exists in the RF, i.e. the Mintrans and Rosmorrechflot. However, at the same time several federal executive authorities, whose systems are unstable and liable to regular administrative changes for many years, simultaneously deal with provision of maritime safety.

In accordance with several regulatory and legal acts the organization and coordination of operations of various organizations in the national response system fall within competence of several departments at the same time, but the legally grounded mechanism for integration of the facility response systems, including commercial SRUs to the national system is missing. The system is also in default of a legally grounded mechanism for assistance rendered by various organizations and departments in case of a national scale oil spill. Thus, for example, in accordance with the Norwegian Pollution Control Act (The Norwegian Pollution Control Act, 1981), organizations that are prescribed by law to create their own private (site-) oil spill response systems, are required to provide the machinery, equipment and personnel at the request of the municipality, managing the oil spill response operations. Also, other municipalities are obliged to provide all possible assistance to this municipality. If the the oil spill response operation is of a national scale, the organizations and municipalities are obliged to provide assistance upon request of the supervisory authority (The Norwegian Coastal Administration in Norway). However, it is important to note that as per the Norwegian practice, the obligation to support oil spill response operations is reimursable by law. The Russian legislation does not provide for such compensation. Therefore, any Russian organization with site oil spill response system has the right to refuse utilization of its equipment and personnel.

Imperfection of the contingency planning system of oil spill prevention and response, based on development of OSR facility contingency plans, gives possibility for subjective approach during agreement and approval of the contingency plan by the control bodies. The existing procedure of OSR contingency plans agreement and approval on the regional and federal tier lasts for years and creates ground for long-term dispute and court hearings, as well as favourable climate for corruption, especially in cases when absence of an approved OSR contingency plan creates a barrier for the organization to get a licence for its activities.

The funding of oil spill response preparedness makes also a grand problem. In spite of the law stipulating, that the oil spill response preparedness outside the operation area of organizations dealing with offshore oil activities is a governmental objective, the state in practice does not allocate any funding for solution these problems. Normally the response operations at emergency oil spills must be commenced immediately. The special-purpose federal fund, being the financial source for reimbursement of total expenditure linked with potential oil spill response preparedness and existing in certain Arctic countries is missing in the RF. Also a Law providing for obligatory insurance of respective risks is missing.

Based on the opinion of Russian experts and specialists in OSR, the applicable Russian legislation does not provide for, and in many cases counteracts the establishment of an efficient national OSR system at sea. Consequently in case of a vast oil spill of national scale, the national OSR system of Russia will not be able to act as a unified well-coordinated system, which can cause catastrophic effects.

Due to complete absence of purely national Russian legal requirements to the Arctic zone environment protection, one can state that the Russian Arctic does not up to now have a legal base for environmental safety in oil and petroleum product transportation activities. The only legal documents, that can be referred to, are the international acts, appertaining to the Arctic and bearing the character of a soft law (recommendations, declarations, etc). The Russian Federation fully ignores the peculiarities of the Arctic seas. Russian experts and specialists in OSR have for many years underlined the necessity of adoption of the Law on Maritime Oil Pollution Protection in the RF, where the most important international legal principles and recommendations on the Arctic resources could be taken into consideration (The draft Federal Law concept "On Maritime Protection…", 2009). Until adoption of such Law has not taken place, one can state that at present the national rigid legal regulation of utilization and protection of the Arctic resources in Russia is lacking.

2.5 Assessment of Efficiency of Regulatory Support to International Cooperation of the Arctic Countries in Oil Spill Prevention and Response in the Arctic

In case of potential oil spill within or outside the boundaries of exclusive economic zones of separate countries, there arises the problem of interaction between special organizations of two and more countries for the ecological disaster elimination. Such interaction must be based on respective national and international legislative and regulatory acts and be accurately coordinated. Also join coordinated efforts are required for the oil spill protection and response actions. Oil spill prevention and response must be carried out within the framework of legal clarity in control and monitoring the Arctic environment, applying effective economic and financial control tools in various activities and environmental risk classification.

2.5.1 Intergovernmental Agreements

Russia is a partner in bilateral and multilateral intergovernmental agreements on cooperation during oil spill response with the countries-members of the Arctic and Barents Euro-Arctic region, namely:

- The Agreement between the USSR and the Government of the Finland Republic on cooperation in combating pollution of the Baltic Sea caused by oil or other harmful substances in emergency situations, 1989;
- The Agreement between the Government of the USSR and the Government of the USA for cooperation in combating pollution in the Bering and Chukchee Seas in emergency situations, 1989;

- The Agreement between the Government of the RF and the Government of the Kingdom of Norway on cooperation in combating emergency spills in the Barents Sea, 1994;
- The Agreement between the countries-members of the Barents Euro-Arctic Region on cooperation in emergency prevention, preparedness and response, 2008.

We shall consider the basic provisions of the Agreements Russia-US and Russia-Norway, as they appertain to interaction between the Arctic countries on waters of the Arctic seas (the Barents, Bering and Chukchee Seas), as well as the Agreement between the governments of the countries-BEAC members.

Agreement Russia-Norway

The Agreement between the Government of the RF and the Government of the Kingdom of Norway on cooperation in combating emergency spills in the Barents Sea was approved by the Government Resolution of the RF РФ of 24.05.1994 No. 545 (Соглашение...,1994).

The Agreement provides for rendering counter assistance in combating oil pollution incidents, that may affect areas of responsibility of the Parties, no matter where such accidents may occur. For this purpose the Parties' competent bodies have developed and put into force in 1994 the Joint Contingency Plan for Combatment of Oil Pollution in the Barents Sea (The Joint Contingency Plan). The Joint Contingency Plan can be put into effect in case of any accident linked with emergency and/or emergency risk of oil spill in the areas of responsibility of the Parties, or in the area of responsibility of one of the Parties, provided the spill scale justifies the appeal to the other Party for support. The competent bodies bear the major liability for execution of the Joint Contingency Plan, as well as other bodies of the Parties within the area of their responsibility.

«The competent authority» within the frames of the Agreement with regard to the RF is FSI Gosmosspassluzhba of Russia under Rosmorrechflot of the Ministry of Transport of the RF; with regard to Norway – the Norwegian Coastal Administration (NCA).

The competent bodies within the framework of the Agreement have established a Joint Preparedness Group (JPG), where representative of FSI Gosmorspassluzhba of Russia and FSUE Murmansk BASU are members from the Russian side and representatives of NCA from the Norwegian side.

The Parties under the Agreement counteract in the day-to-day mode and the emergency situation mode. In the day-to-day mode the Parties carry out actions as follows:

- Annual JPG meetings: action planning for the year to come, amendments to the Join Contingency Plan, update on accidental oil spills on Russian and Norwegian sides, information exchange and mutual consulting for the purpose of adequate cooperation between the competent bodies in all matters appertaining to the Agreement and the Joint Competency Plan;
- Joint training exercises. Each Party bears relevant expenses for joint training exercises on its own discretion.

Should an emergency situation occur the competent body of the Party shall immediately notify the competent body of the other Party on the incident, that causes oil pollution and can affect the area of responsibility of the other Party. Such notification shall be made as per procedures stipulated for by the Joint Contingency Plan.

Operation control over pollution combating shall be carried out by the Competent Body of the Party, whose area of responsibility has been affected by the oil pollution incident.

The Party, that has appealed for assistance, shall at the highest possible degree simplify arrival and departure of the response forces rendered by the other Party, providing assistance in operations for combating the oil pollution, as set by the Agreement.

The Party that has appealed for assistance, shall reimburse expenditure linked with assignation of the response forces to the other Party.

Agreement USSR (Russia)-US

The Agreement between the Government of the USSR and the Government of the USA concerning cooperation in combating pollution in the Bering and Chukchee Seas in emergency situations was signed on May 11, 1989 (Соглашение..., 1989).

Within the frames of the Agreement the Parties have bound themselves to:

- To render support to each other in combating incidents causing pollution that can affect areas of responsibilities of the Parties, regardless of the place of such incident;
- In conformity with Parties' potentialities to develop national systems for detection and immediate notification about an incident, or real incident hazard, causing pollution, as well as assign appropriate means, being at the Parties' disposal, for the purpose of elimination of the hazard created by such incidents, to mitigate the harmful effect on the marine environment, as well as the population health and wellbeing.
- To provide for regular information exchange and consulting for the purpose of adequate cooperation between the competitive bodies.

With regard to the USSR «the competitive body» meant – the Department of State Special Service for Oil and Petroleum Product Spill Response at sea under the Ministry of Commercial Marine Fleet of the USSR (Gosmorspecsluzhba), at present the functions of a competent national body are imposed on Rosmorrechflot and FSI Gosmorspassluzhba of Russia under the Mintrans of Russia, with regard to US – the US Coastal Guard.

For execution of joint objectives within the framework of the Agreement the Parties have developed the Joint Contingency plan for emergency operations for combating pollution in the Bering and Chukchee Seas (The Plan). The competent bodies of the Parties, as well as other bodies of the Parties within their area of responsibility bear major responsibility for execution of the Plan. The Plan can be put into effect in case of any incident causing pollution, which affects of can affect the areas of responsibilities of the Parties, or affecting the area of responsibility of only one of the Parties possess the scale which justifies the appeal to the other Party for support.

The basic provisions on the parties' interaction are as follows:

- The competent body of the Party, in whose area of responsibility the pollution incident took place, or whose area of responsibility is affected by such incident, shall perform operation control of the response action in this area;
- Appeals for assistance shall be transmitted by communication means between the competent bodies of both Parties;
- The Party shall do its utmost to render the requested assistance as soon as possible and in the scope that is determined based on the response forces the Party has at disposal. With it the Parties understand that the possibility to render assistance for the occurred pollution incident depends on funding and requirement of such forces for other purposes.

- The Party applying for assistance shall render all possible support to the response forces of the Party granting such assistance.
- The Assistance Granting Party can fully or partially suspend the support, should it consider such action to be necessary. The notification on the support suspension shall be passed to the competent body of the Party applying for assistance. The Party who applied for assistance shall release the assigned response forces as soon as possible on the support suspension. The Party who applied for assistance shall immediately notify the Party granting the support on the moment when the necessity in further support disappears and releases the response forces granted by the other Party.
- The Parties shall from time to time arrange joint training exercises in pollution combating and meetings in accordance with the Plan provisions. The competent bodies of the Parties shall control the training exercises in rotation.
- The Party applying for assistance shall at its utmost simplify arrival and departure of the response forces, assigned by the other party for response operations, appertaining to the present Agreement.
- The Party applying for assistance shall reimburse expenditure linked with the response forces to the other Party. In any other cases or circumstances should the agreement not rule otherwise, each Party shall bear their own expenditure linked to the operations appertaining to the present Agreement.
- Each Party bears relevant expenses for joint training exercises on its own discretion.

Agreement between the Governments of countries-BEAC members

Signing of the Agreement between the Governments of the countries-BEAC members on cooperation within the field of emergency prevention, preparedness and response of 11.12.2008 (Соглашение.., 2008) was caused by the growing activity in the northern regions and increased number of emergency situations, expanding demand in forces and technical facilities for combating various emergency situations in the Barents Euro-Arctic region. The Agreement is aimed at development of direct transboundary cooperation at the local and regional tier and provides for timely prevention and control, of emergency situation, mitigation and elimination of the ES effects.

The Agreement was signed by the Government of the Kingdom of Norway, the Russian Federation, the Republic of Finland and the Kingdom of Sweden. The competent bodies within the framework of the Agreement, responsible for operation control and coordination of the Agreement fulfillment are as follows:

- In the Kingdom of Norway – the Ministry of Justice and the Police of the Kingdom of Norway;
- In the Russian Federation – the Ministry of the Russian Federation of Civil Defense, Emergencies and Elimination of Consequences of Natural Disasters (EMERCOM of Russia);
- In the Republic of Finland – the Ministry of Internal Affairs of the Republic of Finland;
- In the Kingdom of Sweden – the Ministry of Defence of the Kingdom of Sweden;

The Agreement also provides for regional and local competent bodies, namely municipality managerial bodies, united municipalities and local governments, as well as district administrative bodies and relevant state bodies as part of local administrations in the Barents Euro-Arctic region, empowered to decide on matters falling within the scope of the Agreement.

For the purpose of fulfillment of the Agreement the competent bodies have established a Joint Commission, where the presidential Chair is devolved to the representatives of the Agreement Parties by annual rotation in the alphabetical order. The functions of the Joint Commission include initiation and participation in joint training exercises, upgrade of the "Joint Operations Manual" and exchange of experts. The operational information on prevention preparedness and response in the Barents Euro-Arctic is presented in the "Joint Operations Manual".

Cooperation within the framework of the Agreement is carried out in the day-to-day operation mode and the emergency situation mode. The day-to-day operation mode includes development of methods and taking joint actions, including joint training and exercises for the purpose of improvement of emergency response efficiency and flexibility, as well as efficiency of the international cooperation in emergency prevention, preparedness and response. The Joint Commission holds annual meetings for contingency planning and cooperation coordination, as well as assessment of execution of the present Agreement.

In the Emergency Situation mode the Party to the Agreement requesting assistance shall forward the appeal for assistance to the other Party (Parties), where it shall notify on the place, time, character and scale of the Emergency Situation, as well as on the type and scope of the requested support. The Emergency Situation notification shall pass the Joint Commission. Notifications on marine emergency situations shall be forwarded in compliance with the procedure as set by international conventions and bilateral agreements.

Each Party shall consider the appeal of the Requesting Party in shortest possible terms and shall promptly notify it on possibility, scope and conditions of the support. The Requesting Party shall notify the Assisting Party on which of response teams and response resources it is ready to receive.

The Assisting Party shall transfer to the Requesting Party an organized emergency response team (the response team) operating under the authority of a single commander. The Requesting Party and the transit states shall apply in accordance with the national legislation and international liabilities the utmost simplified frontier passage procedures for response cargoes and forces of the Assisting Party including sea vessels approved for emergency effect response on the territory of the Requesting country.

The Parties shall apply relevant national legislation and international liabilities appertaining to customs duty exemption and other miscellaneous duties and fees at import, transit and export of the emergency response resources on the territory of the Parties to the Agreement. The responsibility for operational control in the emergency area shall be imposed on the competent body of the Requesting Party, exclusive of the areas, which may lie on the territory of the other Party to the Agreement. The competent body of the Requesting Party shall organize and control operational actions by the response team of the Assisting Party.

Provisions of the Agreement of the BEAC countries-members of 11.12.2008, as well as the Agreement of the RF with Norway and the US are clearly specified with regard to basic items of interaction at oil spill response, namely operational control of response actions, communication, aid, expenditure reimbursement.

Provisions on regular joint training exercises and meetings of working teams for joint contingency planning are an indubitable advantage of the Agreements; practical cooperation matters are tuned and upgrades of the joint contingency plans are made during such training exercises and meetings.

However, experts already face the necessity for the Arctic countries to solve certain issues in oil spill prevention and response in the Arctic, namely necessity in search for joint solutions in the following directions:

- Synchronization of the regulatory and legal framework;
- Development of emergency prognosis and simulation methods, including ES caused by natural disasters;
- Managerial solutions coordination;
- Unification of oil and petroleum product pollution norms;
- Risk management;
- Qualified personnel training development in response to oil spill effects.

Development of the regulatory and legislative framework must become one of the top priority targets in OS prevention and response in the RF. With it the legal regulations must be long-term efficiency oriented and synchronized with managerial solutions with the other countries, and with the Arctic countries in the first run.

2.6 Top-Priority Directions of Actions for Improvement of Oil Spill Response System in the Arctic Zone of the Russian Federation

Improvement of the OSR system in the Arctic zone of the RF is possible only within the framework of reforms in the Russian national OSR system in general.

The top-priority directions for improvement of the national OSR system in the RF are clearly presented in the Resolution by participants of the research and practical seminar «OSR: contingency planning, preparedness and response. Regulatory requirements and execution practice», organized by the State Maritime Academy named after Admiral S.O.Makarov in cooperation with the North-West Regional Centre of the EMERCOM of Russia and FSI Gosmorspassluzhba of Russia in April 2010. The representatives of the North-West Regional Centre of the EMERCOM of Russia, seaport administrations, FSI Gosmorspassluzhba of Russia, maritime educational institutions, oil and petroleum product supply companies salvage and rescue units, OSR facility manufacturers and other concerned organizations and companies participated in the seminar. Total number of participants reached 82 persons from 57 organizations.

The seminar participants outlined certain top priority issues requiring urgent solution and additional consideration and applied to the Government of the RF, the Commission on Maritime Policy under the Federation Council, the Ministry of Transport of the RF, the Ministry of Civil Defense, Emergencies and Elimination of Consequences of Natural Disasters, the Federal Service for Transport Control, The Department of Fire-Fighting and Rescue, Specialized Fire-Fighting Guard and Civil Defense of the EMERCOM of Russia, the Department of Federal Support of Territories of the EMERCOM of Russia with the following proposals:

1. Revise the OSR existing contingency planning system at all tiers;
2. Develop and put in effect a manual for OSR contingency planning for commercial marine organizations;
3. Revise the norms for OSR deadlines with regard to international practices;
4. Agree the provisions of the basic regulatory and legislative acts and documents regulating OSR actions and bring the contradictory provisions in conformity with each other;
5. Insert changes in the Regulation on RS ES using more accurate terms and determinations, determine the base for support of the system at each tier;

6. Establish a clear system of state bodies with clear distribution of competency and sufficient funding of the effective activity.
7. Establish a national OSR system where the state and commercial SRUs could be united provided their functions are clearly split.
8. Apply obligatory risk insurance linked to utilization of marine resources at operations with oil and petroleum products.
9. Establish a special fund to serve as the basic funding source for all expenses linked to oil spill response preparedness.
10. Put into effect a Federal Law "On Protection of Russian Seas from Oil Pollution», where the important international legal principles and recommendations appertaining to Arctic resources protection could be taken into account, this Law could enable to carry out the following targets:

- Mitigate marine environment pollution and provide for stable development of the RF subjects, whose territories are adjacent to the offshore zone;
- Exclude inaccurate interpretation of requirements to marine environment protection in various normative acts;
- Standardize requirements to sea vessels, ports and environment protection facilities;
- Provide for due oil spill response preparedness;
- Set the funding procedure for environment protection measures;
- Establish an effective OS prevention and response system, meeting the requirements of the international norms and standards.

3 PREPARATION OF SPECIFIC SENSITIVITY MAPS OF COASTAL SITES TO OIL SPILL IN THE BARENTS AND THE WHITE SEAS

Pursuant to the Russian Federation national requirements (RF Government Regulation No. 613 d.d. 21.08.2000, RF Government Regulation No. 240 d.d. 15.04.2002), planning of OSR operations and selection of the sites of priority protection must be performed based upon the risk assessment considering conditions of the area, pattern of the land or marine area utilization and its particular environmental characteristics. Concurrently data on distribution of various types of fauna and flora in the area affected by oil spill, availability of particularly protected natural areas (PPNA), any other outstanding natural sites, aquaculture enterprises and etc. usually constitute prevailing information. The international practice (Gundlach, Hayes, 1995; Sensitivity ..., 1996) for coast areas, where a risk of oil pollution exists, recommends developing special maps which depict mentioned sites and areas sensitive to oil spills.

Sensitivity maps can be used both under planning of OSR operations for a specific coast area, for instance, when developing oil spill contingency plans (OSR plans), and in case of actual oil spill. Use of maps makes possible preliminary assessment of damage which can be caused as a result of oil spill and immediate definition of priority protection areas.

At present oil spill sensitivity maps are not yet that widely used in Russia as in western countries. Need for their availability, development methods and their contents are not yet regulated at the federal level. There is no complete certainty pertaining terminology (vulnerability, sensitivity and etc.). In many science publications there is a tendency to widely apply term “vulnerability” of water areas and ecosystems jointly with term “sensitivity”. In the context of the present report **sensitivity** *of the sea area (natural habitat of the sea area and inhabiting biota) is a characteristic describing consequences of probable negative or positive effect stated in parameters that specify a direct loss of numeroscity or biomass of separate species or even complete ecological groups under a direct human impact or immediately after it, or a reduction of their usual activity and fertility starting as of the impact date and continuing for a long time, possibly, even when the impact has already terminated.* When the impact is over, the environment and biocoenosis can return to its original condition over some period of time, but it can happen that the biocoenosis of the region of impact migrates to another stable condition other than original. In these circumstances vulnerability of organisms to the human impact depends on their sensitivity to different types of impact and their ability to recover initial abundance and structure of populations after the impact termination.

Relative sensitivity coefficients of biota components and maps of integral sensitivity for Barents and White Seas (items 3.1 – 3.3 of the present) have been developed on the basis of the proposed approach to the sensitivity interpretation. This report also contains recommendations for the development of sensitivity maps (vulnerability) of coastal areas to oil spills (item 3.4) and proposals for improvement of the methods of mapping the sensitivity of seas and coasts to oil pollution (item 3.5). All original materials are given in Appendices B-C.

3.1 Methods for Mapping of the Integral Sensitivity of the Barents and the White Seas to Oil Spills

At present there are several approaches to the mapping of sensitivity of water and coastal areas. *The ESI mapping system recommended by international organisations IMO and IPIECA* is recognized and widely applied in Europe (Sensitivity…, 1996). This approach mainly considers physical characteristics of different types of coasts with relation to the duration of oil preservation on shore. *The MOB Method for identification and priority of environmental resources at acute oil spill* is applied in Norway (Методика …, 2004). This method considers both shoreline and coastal water areas and reviews biological, geographical and physical (chemical) components of the environment. In Russia *the method of integral assessment of the water areas sensitivity by ZAO Ecoproject* is frequently used (Интегральная оценка ..., 1999; Погребов, Пузаченко, 2000, 2003а; 2003б; Pogrebov, Puzachenko, 2001), and it considers biotic components of the ecosystem, data on distribution of substances and their sensitivity to the main types of impacts related to development of offshore oil fields.

The method described below was applied in the report to calculate and to develop the integral sensitivity maps of the Barents and the White seas. The method is based on and partially reduplicates the guidelines from the method by ZAO Ecoproject.

Integral sensitivity of the area is defined as a result of the sum of the products of ranked numerosity/biomass of the biota component in the definite season (see Appendices B, C) by the sensitivity index of this component to the oil impact. Consequently, integral sensitivity maps of the analyzed area for each of the seasons are developed on the basis of data on the distribution of the overall (integral) sensitivity.

A programme module that allows "summing" of the maps of distribution of various parameters using the below formula was established as a tool for calculation of the integral sensitivity (IS) in the ArcGIS 9 system using Visual Basic for Applications programming language:

$$IS = W_p \cdot Y_p + W_z \cdot Y_z + W_i \cdot Y_i + W_b \cdot Y_b + W_f \cdot Y_f + W_m \cdot Y_m + W_o \cdot Y_o \qquad (3.1)$$

where Y_p, Y_z, Y_i, Y_b, Y_f, Y_m, Y_o, – ranked numerosity or biomass of the substance (component of the ecosystem); value of ranks from 0 until 3 for phyto- (p), zoo- (z), ichthyoplankton (i), benthos (b), avifauna (birds) (o); from 0 until 5 for fish (ichthyofauna) (f) and marine mammals (m); W_p, W_z, W_i, W_b, W_f, W_m, W_o, – defined indices of relative sensitivity for each of the analysed components of the ecosystem depending on the level of oil impact to them (Table 3.1).

Calculation of sensitivity indices (W) for selected components has been carried out based upon the definition of the group sensitivity concentration (GSC) to oil impact for each of these environmental groups of hydrobionts (Оценка..., 2009a). Concentration of oil in water excess of which causes not only physiological disruption and reduction of fertility but massive mortality for most of the species in the group has been accepted as the GSC. Based upon the analysis of the available experiment data on the oil and oil products impact to the reviewed ecological groups of hydrobionts (отчет «Оценка..., 2009a» глава 5, рис. 5.5; Приложение Б) were identified their concentrations of group sensitivity (Table 3.1, Columns 1, 2). However application of indices differed by more than 5 orders is very inconvenient. Therefore, a logarithmic scale was used for further calculations (Table 3.1, Column 3). In particular, the less sensitive component (marine mammals have got the highest GSC) were assigned sensitivity index W equal to 1, subsequently, the maximum sensitive component (ichthyoplankton and aquatic birds have got the lowest GSC) receives the maximum sensitivity index (Table 3.1, column 4). As a result sensitivity indices W were calculated for each ecological group (Table 3.1, column 5).

Table 3.1. Calculation of sensitivity indices on the basis of group sensitivity concentration GSC for main environmental groups of aquatic organisms (hydrobionts)

Hydrobiont Group	GSC, mg/l	lg (GSC)	max lg(GSC)+(1-lg(GSC))	W
1	*2*	*3*	*4*	*5*
Phytoplankton	100	2	5.3 +(1 – 2) = 4.3	**4.3**
Zooplankton	10	1	5.3 +(1 – 1) = 5.3	**5.3**

Ichthyoplankton	1	0	5.3 +(1 – 0) = 6.3	**6.3**
Zoobenthos	25	1.4	5.3 +(1 – 1.4) = 4.9	**4.9**
Ichthyofauna	1500	3.2	5.3 +(1 – 3.2) = 3.1	**3.1**
Birds	1	0	5.3 +(1 – 0) = 6.3	**6.3**
Marine mammals	$2{\cdot}10^5$	5.3	5.3 +(1 – 5.3) = 1.0	**1.0**

The most grade of sensitivity from the oil pollutions is adopted for ichthyoplankton (Wi=6.3, Table 3.1, Column 5) – fish eggs and early stage (larvae) of hydrobionts, i.e. at the early stages of development even small concentrations of oil carbohydrates, which are toxic and able to cause demise and irreversible damage to functions, can be dangerous. The same high coefficient of sensitivity is allocated for marine birds habitating in cold weather conditions (Wo=6.3). Marine mammals are less sensitive (Wm=1.0) having the high grade of protection from the environment and complex nervous system that allows them avoiding polluted areas. Full-grown fish has also got abilities to define and avoid areas of significant oil pollution, but due to the permanent habitation in the water environment and absence of protective cover fish is more exposed to the oil impact and is more sensitive than marine mammals and has got a higher coefficient of relative sensitivity (Wf) equal to 3.1. The grade of sensitivity of phyto-, zooplankton and benthos will be interim in the given conditions (Table 3.1, Column 5). Although phytoplankton is usually more exposed to the impact than, for example, benthos or zooplankton, and is significantly faster recovers, therefore it has got a much lower coefficient of sensitivity (Wp=4.3) than zooplankton (Wz=5.3). Detailed description of the oil impact on the different groups of hydrobionts and justification of the applied table 3.1 is givent in the monography (Шавыкин, Ильин, 2010) and in the MMBI report (Оценка…, 2009а).

In the programme to calculate the IS maps to be studied initial data is given in the form of polygonal shapefiles. Areas (polygons) of the rank-abundance (biomass) distribution of each biota component (Annexes B, C) are specified in the maps.

Polygonal maps are transformed into ESRI GRID bit maps with the specified size of the cell in the units of the map. After that the maps of the rank-abundance (biomass) distribution of separate goups of hydrobionts (p, z, I, b, f, m, o) (more accurate – value of the cells in separate maps) are multiplied by the relevant weight coefficients in the programme and summed up pursuant to formula 3.1. The values obtained for the integral sensitivity ranked pursuant to 5-ball scale: 1 – very low-level sensitivity, 2 – low-level etc. up to 5 – very high. In the brackets intervals of the relative sensitivity values ar given – value of the GRIDCODE in nondimensional (nominal) units achieved during the calculations for each of the cells on the map. Marked areas with different sensitivity are highlighted with five colours from dark green to red corresponding to five categories of sensitivity. It should be taken into consideration that differences in sensitivity in the maps are given in the logarithmic scale, i.e. the areas where the IS values are equal to, for example, 2 and 4 differ in sensitivity 100 times.

The analysis of the data obtained can be implemented either pursuant to the absolute values of sensitivity (GRIDCODE value, i.e. values that have been made during the calculations pursuant to formula 3.1 in each cell of the map) or in accordance with the rank values of the corresponding scale. Both the ranks and values of borders of ranks (intervals) are important for analysis. All maps are presented in one geographical perspective. The size of output cell can be presented both in grade and meter grids. Thus, the IS maps for the Barents Sea have been developed using the garde grid with the output cell of 0.13º as latitude and longitude. For the White Sea the IS maps have been developed in the meter grid and the size of the output cell is 3000m.

3.2 Maps of Integral Sensitivity of the Barents and the White Seas to Oil Pollution

The Barents Sea sensitivity maps are prepared in accordance with the methods presented in the publication (Шавыкин, Ильин, 2010), written by the specialists of MMBI of the Kola Science Centre of the Russian Academy of Science on commission from the WWF Barents Sea Branch.

To study and to develop initial and resultant maps the area which covers almost entire Russian Economic Zone (REZ) of the Barents Sea, excluding a small area in the north and north-east of the Barents Sea as well as the “grey” zone in south-west and a part of the Norwegian Exclusive Economic Zone in the north-west of the Barents Sea, has been selected (fig. 3.1). Sea territories in this region are delimited by the Russian-Norwegian Agreement on maritime delimitation and cooperation in the Barents Sea and the Arctic Ocean as of th 15th of September 2010 subject to ratification.

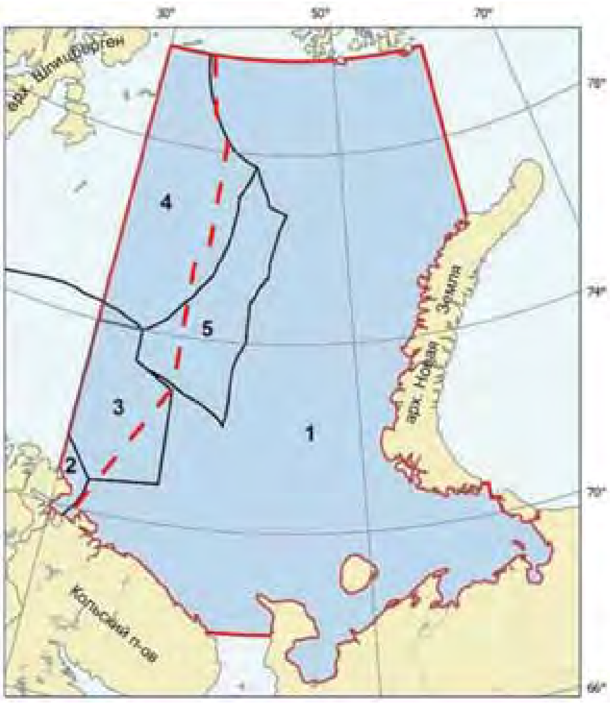


Fig. 3.1. The area of research in the Barents sea:

—— Boundary of the research area in the Barents Sea

- - - Delimitation of maritime delimitation and cooperation in the Barents Sea and the Arctic Ocean as of the 15th of September 2010

1 –exclusive economic zone; 2 – economic zone of Norway; 3 – grey zone[11]*; 4 – fish protected zone of Norway around the Spitsbergen archipelago; 5 – enclave of the open area of the Barents sea*

Considering major spatial extension of the studied water-area of the Barents Sea it is difficult to identify same time lines of the seasons for all its areas. In so doing, even for this particular

[11] In September 2010 the Russian-Norwegian Agreement on maritime delimitation and cooperation in the Barents Sea and the Arctic Ocean was signed in Murmansk. The Agreement stipulates also delimitation of the so-called “grey zone” in the Barents Sea between Russia and Norway. The Agreement shall come in force on ratification by parliaments of both countries.

part of the sea, borders of the seasons defined by calendar, climatic, biological, hydrological, hydrochemical and other parameters do not coincide. Due to this, for the studied area of the Barents Sea the division into seasons pursuant to the balance of heat has been adopted in the project. The issue is discussed in detail in the publication (Шавыкин, Ильин, 2010) and in the MMBI's report (Оценка..., 2009a).

For the sake of the studies' convenience, for unification of the calculation periods and for averaging of the parameters for the Barents Sea the following seasonal breakdown of the year has been adopted:

Winter (I quarter): January–March

Spring (II quarter): April–June

Summer (III quarter): July–September

Autumn (IV quarter): October–December.

To calculate the integral sensitivity (IS) of the Barents Sea in the ArcGIS 9 environment in Visual Basic for Applications using the programme module, "summing" of the abundance/ biomass distribution maps (Y) of each component of biota presented in polygonal shapfiles considering their weight coefficients of sensitivity (W) was done pursuant to formula 3.1. All initial maps of distribution and descriptions of the Barents Sea components are presented in Annex A. Calculation of sensitivity indices W of the selected components has been done on the basis of specification of the group sensitivity concentrations (GSC) to oil impact for each of these ecological gropus of hydrobionts (Table 3.2, Column 4). It was taken into consideration that for the distribution maps ranks 0, 1-5 were accepted for ichthyofauna and marine mammals and 0, 1-3 ranks were adopted for all other components. Therefore weight coefficients for fish (Wf) and marine mammals (Wm) were additionally multiplied by multiplier 3/5 (Table 3.2, Column 4) so that the input of all components approximately corresponded to the initial basic data, and the input to the final maps of sensitivity was defined only by the rank of the components and their coefficients of sensitivity. Sensitivity of benthos significantly depends on the depth. Benthos becomes approximately 2 times more sensitive up to 50m and less due to the potential possibility of direct contact with oil. Therefore doubled values of ranks were originally allocated in the maps for distribution of the fields at these depths. Consequently, the distance from benthos W = 4.9 to the isobathic line is 50m, W = 2.4 is located deeper (Table 3.2, Column 4).

Table 3.2 Coefficients of relative sensitivity of main groups of hydrobionts under the oil pollution of the Barents Sea

Group of Hydrobionts		Index	Initial	Updated pursuant to the rank number	Final
1		*2*	*3*	*4*	*5*
Phytoplankton		p	4.3	4.3	43
Zooplankton		z	5.3	5.3	53
Ichthyoplankton		i	6.3	6.3	63
Benthos	**< 50m**	b	4.9	4.9	49
	> 50m		4.9	4.9:2 = 2.4	24
Fish		f	3.1	3.1·(3:5) = 1.9	19
Marine mammals		m	1.0	1.0·(3:5) = 0.6	6
Birds		o	6.3	6.3	63

Eventually, seasonal maps of the integral sensitivity of the Barents Sea to oil pollution (Fig. 3.2) exclusively of seasonal differences were prepared. Values of the integral sensitivity are ranked pursuant to 5-grade scale where 1 – insignificant sensitivity, 2 – low sensitivity and so on up to 5 – very high sensitivity. Intervals of the integral sensitivity values given in brackets are values of GRIDCODE in dimensionless (nominal) units that were calculated pursuant to the formula (3.1). Areas with different sensitivity were highlighted with 5 colours from dark green to red that correspond to five categories of sensitivity. It should be mentioned that the differences of sensitivity depicted in the maps are given according to the logarithmic scale.

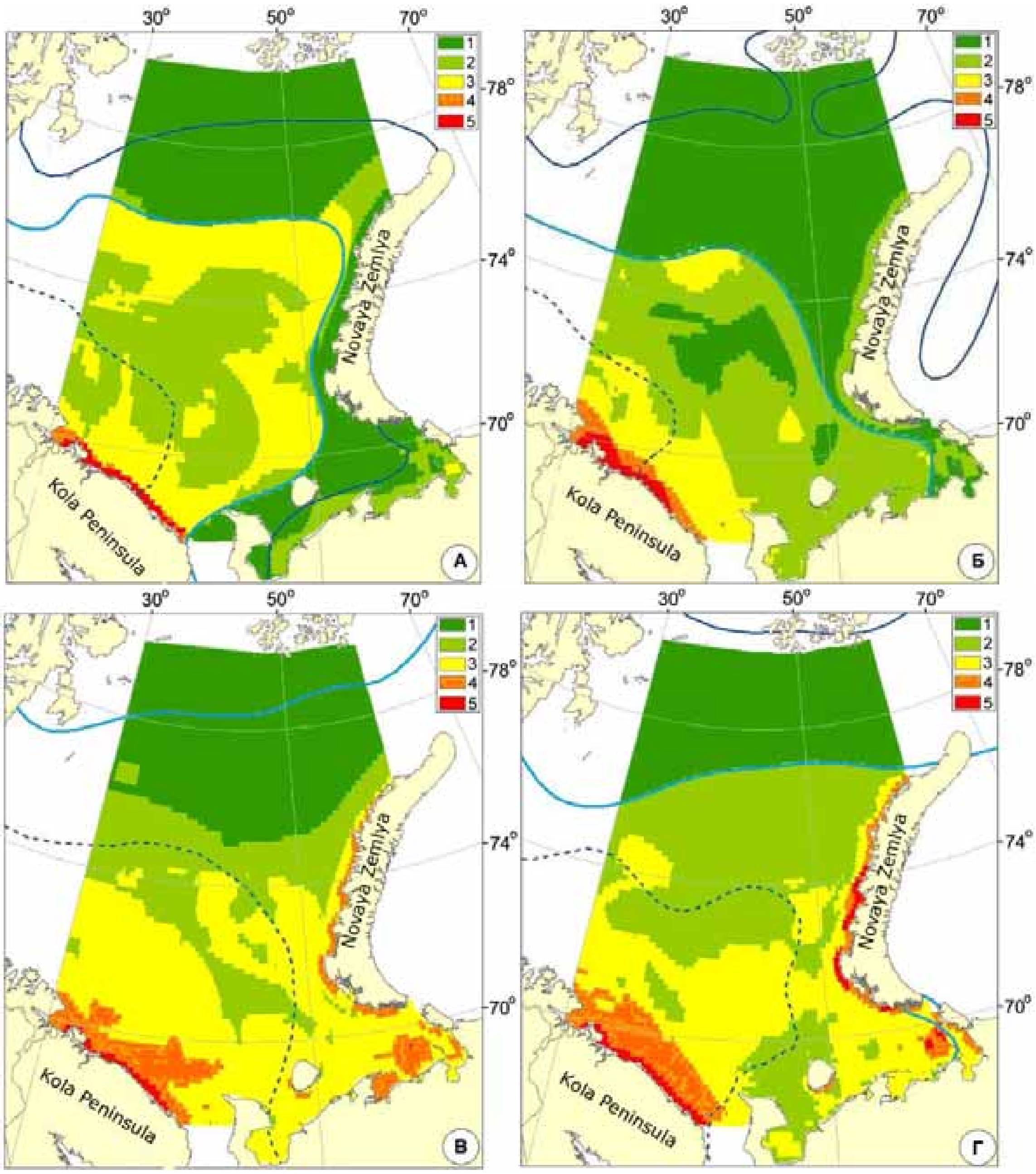


Fig. 3.2. Maps of integral sensitivity of the Barents Sea according to seasons without consideration of seasonal differences in the distribution of hydrobionts: A – winter, Б – spring, В – summer, Г – autumn. Initial distribution of seven components of the ecosystem has been taken into consideration. Coefficients W from Table 3.2 (Column 5 – final coefficient; cell size 0.13º) were applied.

Hereinafter in the figures:

- - - - border of the major distribution of floating ice,

—— average plurannual border of the floating ice distribution,

—— border of the least distribution of floating ice.

minimum sensitivity

maximum sensitivity

Table 3.3. Table of statistical results of map cells classification Fig. 3.2 (in standard units of IS)

Season	«Annual value»	«Mean square value»	max value	min value
Winter	213	96	682	74
Spring	260	118	822	155
Summer	324	155	935	92
Autumn	241	120	693	92

To consider seasonal quantitative differences in distribution of hydrobionts and to compare sensitivity of the Barents Sea between the seasons more properly, based upon the expert evaluations an additional standard seasonal coefficient (SSC) of biota component for each season reflecting the correlation of the abundane (biomass) of each hydrobiont group between the seasons was introduced (Оценка..., 2009a). After that the obtained coefficients were standardized so that the sum of seasonal coefficients for each component became equal to one and the same selected figure per year (in our case – 500; Table 3.4). Obtained standard seasonal coefficients are given in Table 3.5.

Table 3.4. Standard seasonal coefficients to compare the integral sensitivity of the Barents Sea according to seasons (considering expert evaluations)

Component of Ecosystem		Standard Seasonal Coefficients (SSC)			
		Winter	Spring	Summer	Autumn
Phytoplankton		4	384	77	35
Zooplankton		5	124	247	124
Ichthyoplankton		30	290	180	0
Benthos		120	120	140	120
Ichthyofauna (main fish groups)	**pelagic**	22	109	43	87
	bottom-dwelling	11	22	108	98
	migratory	0	0	0	0
Marine mammals		20	150	300	30
Bird fauna		20	160	260	60

Table 3.5. Product of the standard seasonal coefficients SSC (Table 3.4) and relative sensitivity W coefficients (Table 3.1) to compare the integral sensitivity of the Barents Sea areas between the seasons

Component of Ecosystem		W · SSC			
		Winter	Spring	Summer	Autumn
Phytoplankton		172	16 512	3 311	1 505
Zooplankton		265	6 572	13 091	6 572
Ichthyoplankton		1 890	18 270	11 340	0
Benthos *		2 880	2 880	3 360	2 880
Ichthyofauna (main fish groups)	pelagic	418	2071	817	1653
	bottom-dwelling	209	418	2052	1862
	migratory	0	0	0	0
Marine mammals		120	900	1800	180

Bird fauna	1 260	10 080	16 380	3 780

As a result maps of “relative” integral sensitivity of the Barents Sea were developed considering seasonal differences in quantitative parameters of hydrobionts distribution for selected seasons of the year (Fig. 3.3). Coefficients from Table 3.5 obtained after multiplication of the coefficients of the relative sensitivity of the main components of ecosystem (Table 3.1, Column 4) by the standard seasonal coefficients of these components (Table 3.4) were used during the calculations in the programme.

For the comparison of the seasonal differences to be done more demonstrative, these maps should be developed in one and the same ranked scale with similar numerical values of the borders of the rank intervals. For this purpose the maps of all the four seasons were developed according to the integral sensitivity scale divided into five equal intervals beginning from the minimum value of Gridcode 3 501 (winter) up to the maximum value of 164 828 (spring) (Fig. 3.4, Table 3.7).

Thereby, the maps of “integral” and “absolute” sensitivity of the Barents Sea to oil spills were prepared taking into consideration seasonal differences. The maps of “relative” sensibility (Fig. 3.3) allow comparing separate areas of the Barents Sea within one season. To some extent they are the main final maps and the final result which should serve as guiding materials. Moreover, if the comparison of sensitivity between the areas is required, the maps of “absolute” sensitivity of the Barents Sea the maps of “absolute” sensitivity of the Barents Sea to be used (Fig. 3.4).

The resulting maps show that the most sensitive areas of the Barents Sea are coastal areas (Fig. 3.3 - 3.4). First of all, this is a coastal area of Murman – the line along the northern coast of the Kola peninsular with width of 20km in winter, up to 70-120km in spring and up to 140km in autumn as well as the coastal line along the western of the Novaya Zemlya archipelago with width of up to 40km (Fig. 3.3). Eastern areas of the Pechora Sea in winter and autumn are also highly sensitive. The southern part of the Barents Sea is characterized by the mean values of sensitivity in summer up to 74ºN and in winter – up to 71º N and near the edge of ice. Other areas of the Barents Sea have got less sensitivity. The highest sensitivity of the water area happens in spring and summer (Fig. 3.4), besides difference in sensitivity between these seasons is insignificant. The least sensitivity is a characteristic for the winter season though, in the context of accidental spills risks and their mitigation, to be exact winter and autumn are the most hazardous seasons. All water area of the Russian sector of the Barents sea (including areas covered with snow) in summer and spring seasons are approximately 8 times more sensitive then in winter and 2.5 times less sensitive then in autumn.

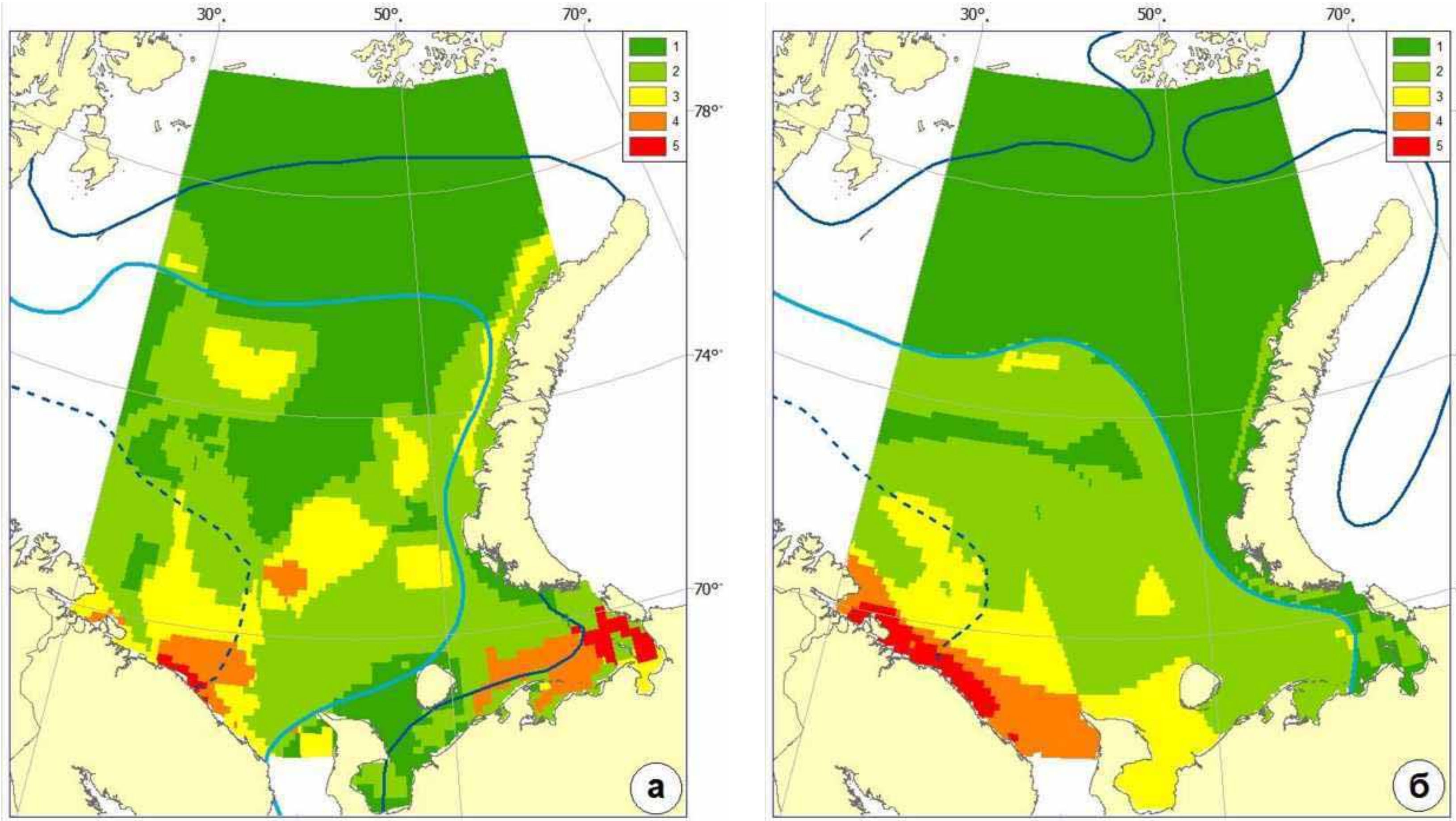


Fig. 3.3 beginning. Maps of "relative" sensitivity of the Barents Sea according to seasons without consideration of seasonal differences in the distribution of hydrobionts: а – winter, б – spring, в – summer, г – autumn. Initial distribution of seven components of the ecosystem (see formula 3.1) has been taken into consideration. Proportional division of the whole range into 5 equal intervals (5 ranks). Coefficients W from Table 3.5 were applied.

- - - - border of the major distribution of floating ice,
—— average plurannual border of the floating ice distribution,
—— border of the least distribution of floating ice.

minimum sensitivity
maximum sensitivity

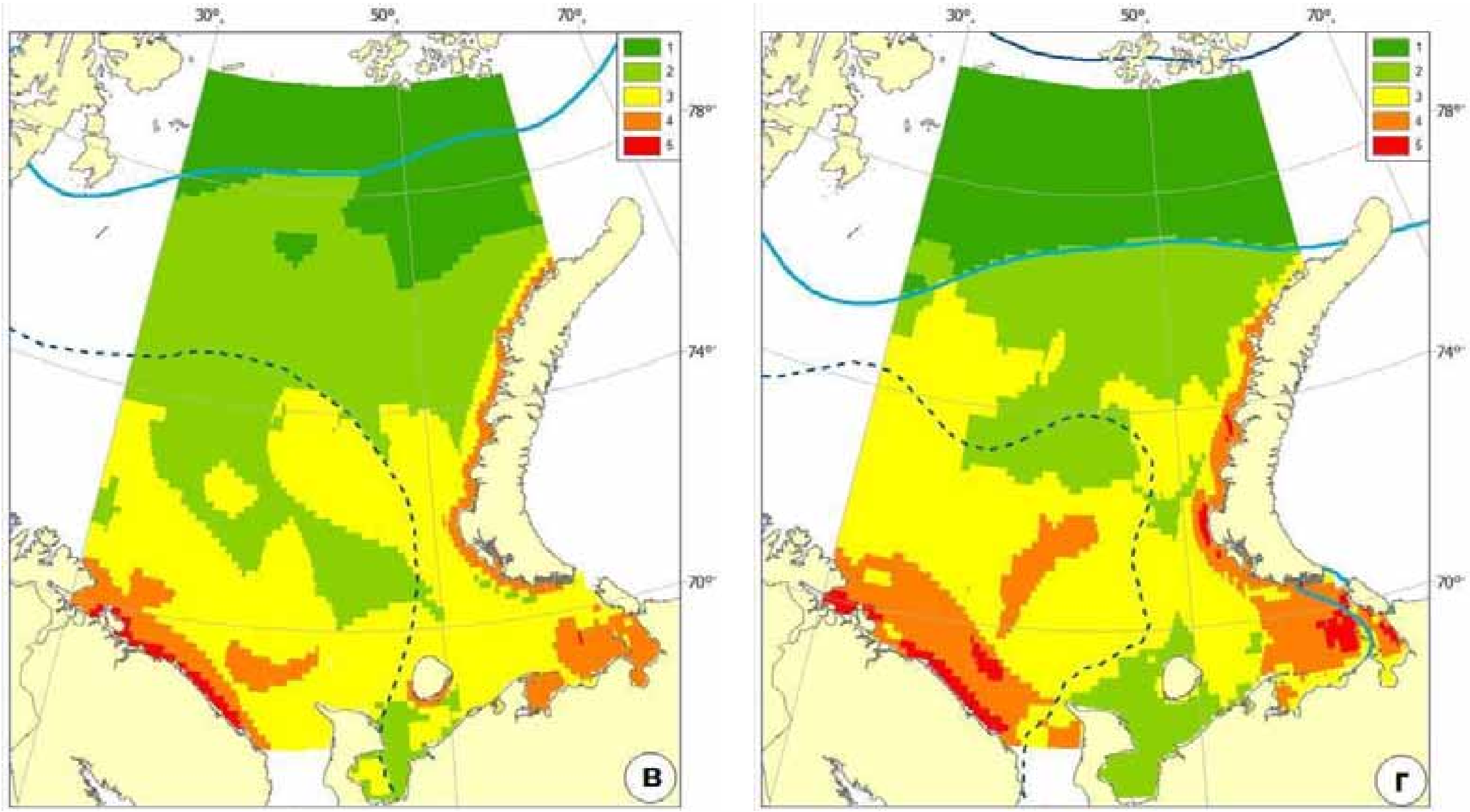


Fig. 3.3 continued

- - - - *border of the major distribution of floating ice,*
—— *average plurannual border of the floating ice distribution,*
—— *border of the least distribution of floating ice.*

minimum sensitivity

maximum sensitivity

Table 3.6. Table of statistical results of map cells classification (Fig. 3.3), in standard units of IS

Season	"Average Value"	«Mean square	max value	min value

		value»		
Winter	6 890	3 553	25 856	621
Spring	54 028	26 240	172 058	30 790
Summer	58 446	28 460	174 237	10 523
Autumn	21 102	11 262	59 615	6 427

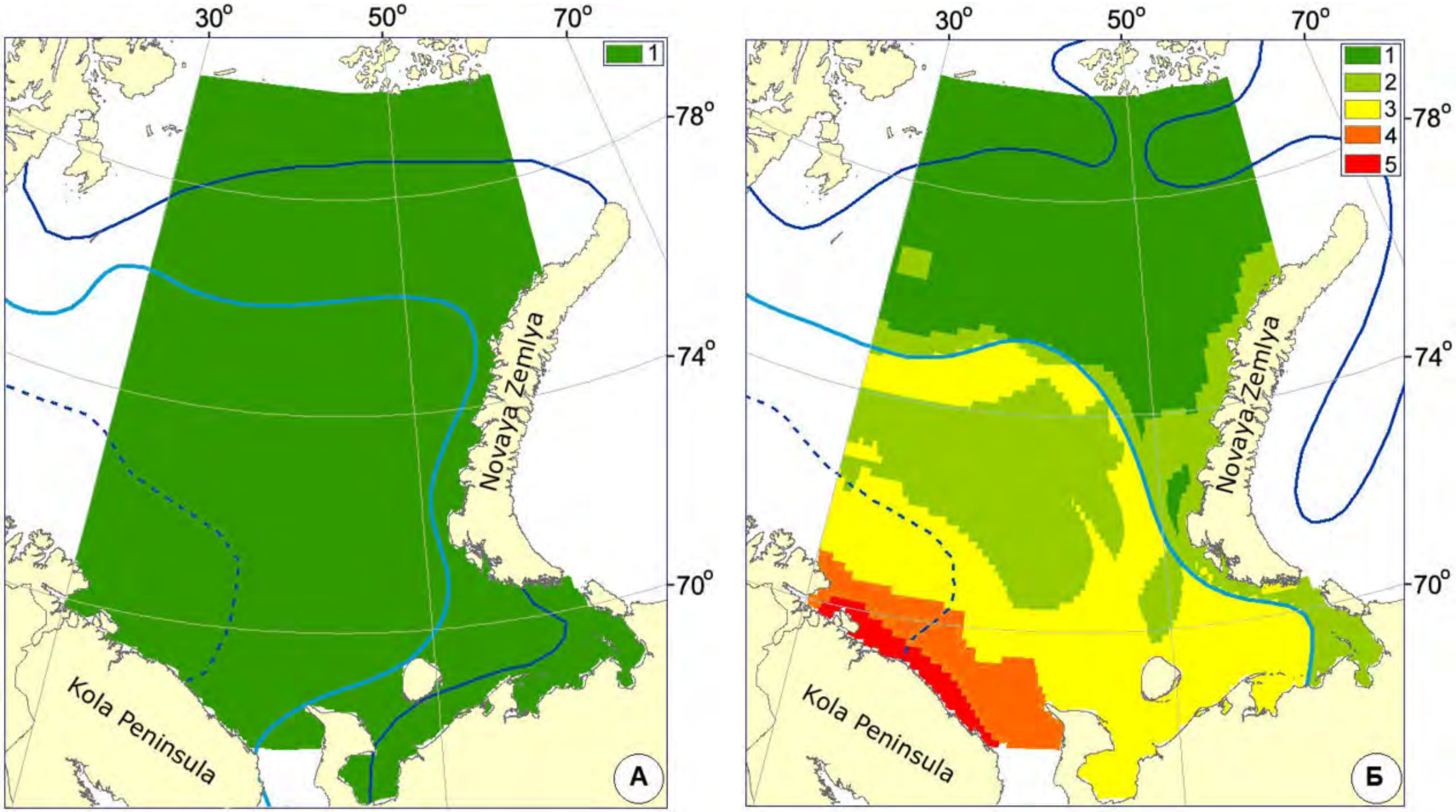


Fig. 3.4 3 beginning. Maps of "absolute" sensitivity of the Barents Sea according to seasons without consideration of seasonal differences in the distribution of hydrobionts: A – winter, Б – spring, В – summer, Г – autumn. Equal intervals of the scale for ranking

the IS of the Barents Sea for all the seasons are given in the range from 3 501 (minimum value for winter) up to 164 828 (maximum for spring). Coefficients W from Table 3.5 were applied.

- - - - border of the major distribution of floating ice,
—— average plurannual border of the floating ice distribution,
—— border of the least distribution of floating ice.

minimum sensitivity
maximum sensitivity

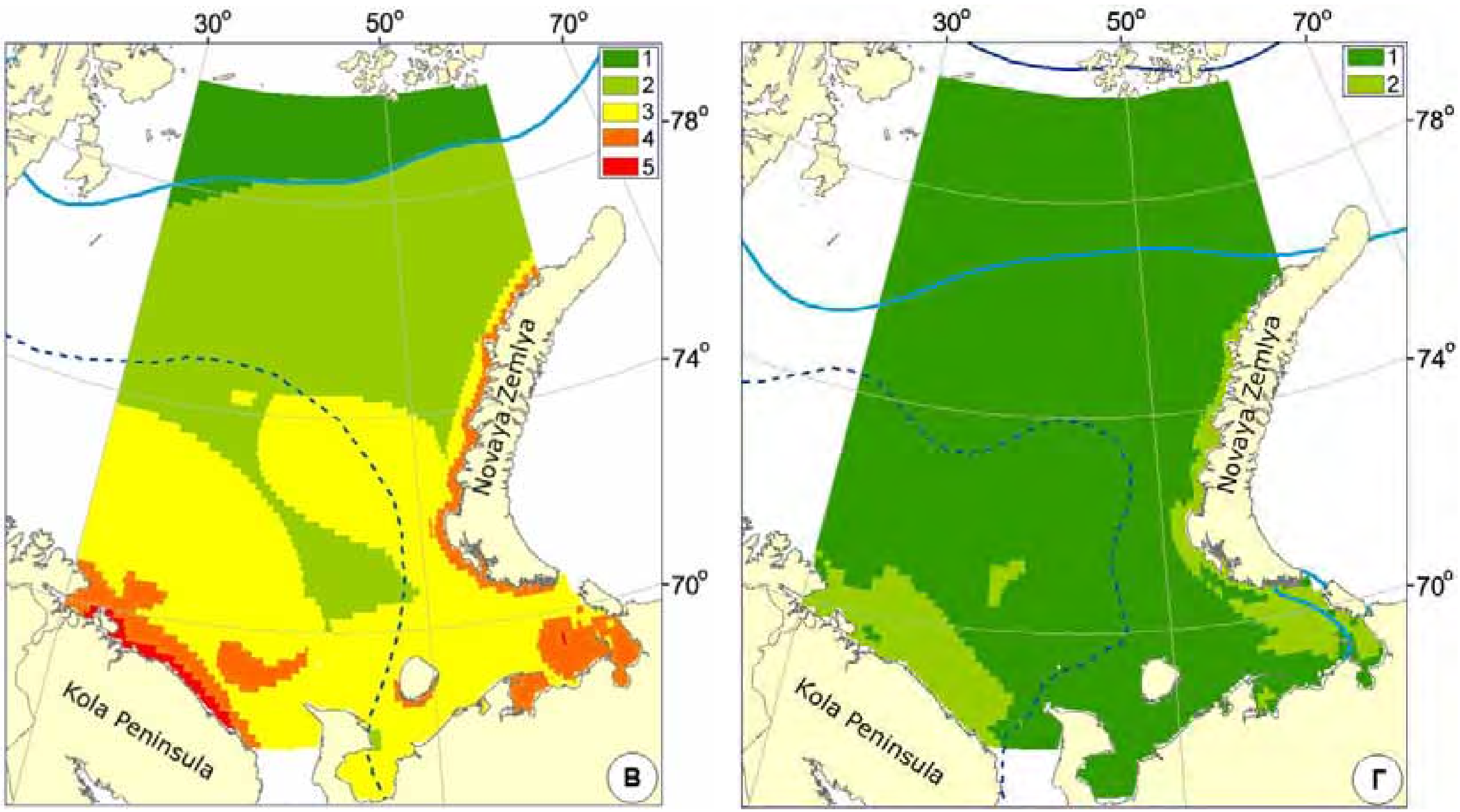


Fig. 3.4 continued

- - - - *border of the major distribution of floating ice,*
—— *average plurannual border of the floating ice distribution,*
—— *border of the least distribution of floating ice.*

minimum sensitivity

maximum sensitivity

Table 3.7: Statistical results of map cells classification (Fig. 3.4), in standard units of IS

Season	"Average Value"	«Mean square value»	max value	min value
Winter	6 502	2 927	18 551	3 501
Spring	54 018	26 443	164 828	30 790
Summer	58 199	27 807	164 157	10 523
Autumn	21 211	10 605	52 103	6 427

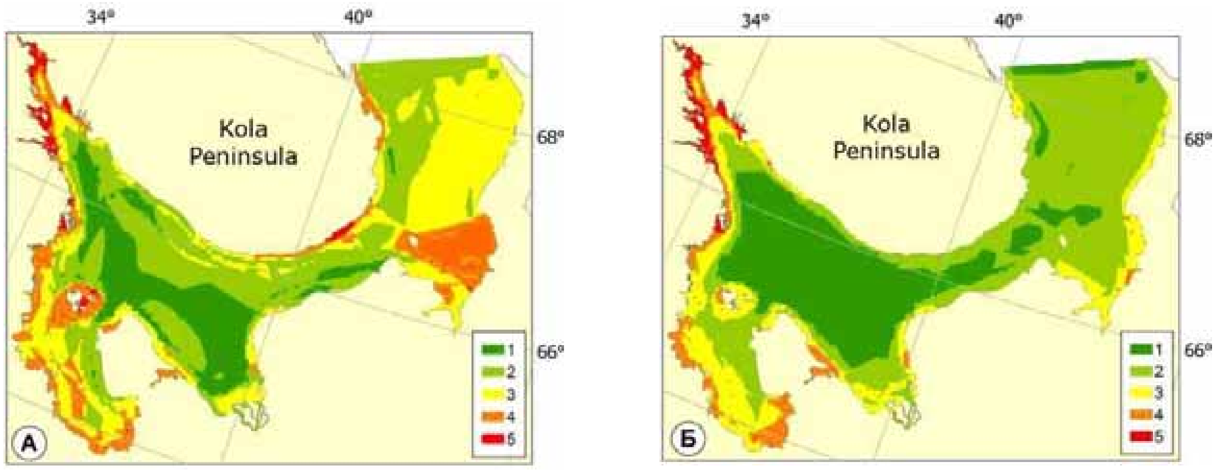
3.3 Maps of Integral Sensitivity of the White Sea in Case of Oil Pollution

A software module with the purpose to produce "summation" of distribution maps for abundance/biomass (Y) of each component of the biota represented as polygon shape files, taking into account weighting factors of sensitivity (W) according to formula 3.1 was used to calculate the integrated sensitivity (IS) for the White Sea, the same as for the Barents Sea. All initial distribution maps and descriptions of the components are presented in Appendix C. Sensitivity Indexes W of the selected components correspond to those of the Barents Sea (Table 3.2) and repeated in table 3.8, column 5.

Table 3.8. The coefficients of the relative sensitivity of major groups of hydrocoles in the White Sea in case of oil pollution

Hydrocole group		Index	Initial	Updated subject to the number of ranks	Total
1		*2*	*3*	*4*	*5*
Phytoplankton		p	4.3	4.3	43
Zooplankton		z	5.3	5.3	53
Ichthyoplankton		i	6.3	6.3	63
Benthos	**< 50 m**	b	4.9	4.9	49
	> 50 m		4.9	4.9:2 = 2.4	24
Fish		f	3.1	3.1·(3:5) = 1.9	19
Marine mammals		m	1.0	1.0·(3:5) = 0.6	6
Birds		o	6.3	6.3	63

As a result maps of seasonal integrated sensitivity of the White Sea to oil pollution (Figure 3.5), not taking into account seasonal differences, were obtained. The values of the integrated sensitivity are ranked by a 5-point scale: 1 - the lowest sensitivity, 5 - the highest sensitivity



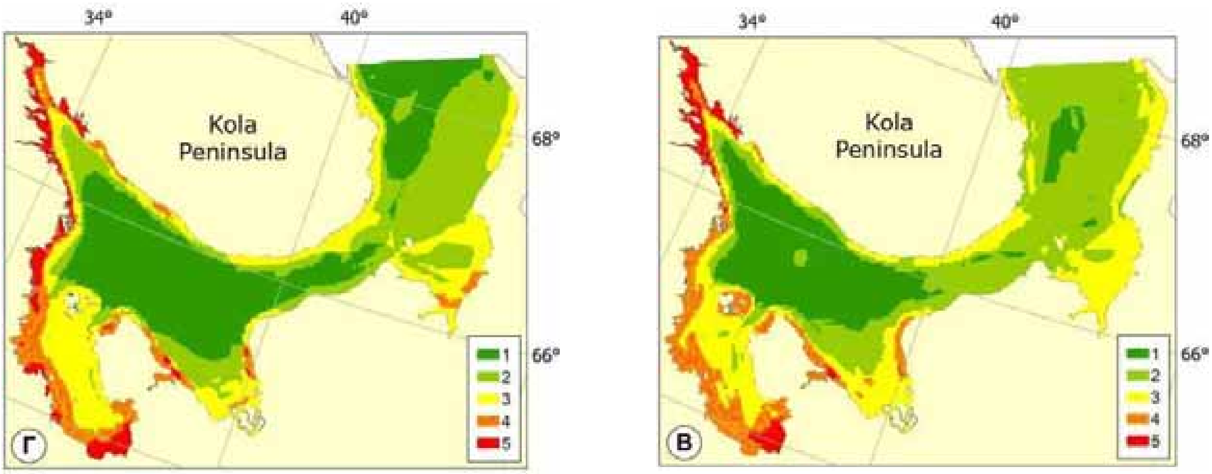


Fig. 3.5. Maps of "relative" integrated sensitivity of the White Sea in different seasons without seasonal differences in the distribution of hydrocoles: A - Winter, Б - Spring, В - Summer, Г - Autumn. The coefficients W from Table 3.8 were used (column 5 - the total coefficient; the cell size is 3000mº)

minimum sensitivity

maximum sensitivity

Table 3.9: The results of the classification statistic of map cells in Fig. 3.5 (in conventional units of IS)

Season	Average	Standard deviation	Max value	Min value
Winter	9	3	16	3
Spring	16	5	29	6
Summer	16	4	28	6
Autumn	14	4	23	6

Intervals of integrated sensitivity listed in Table. 3.9 are the values of GRIDCODE in dimensionless (conventional) units, obtained by calculations with formula (3.1). Sections with different sensitivity were marked by 5 colors from dark green to red, corresponding to five grades of sensitivity. It should be noted that the resulting differences in the maps of sensitivity are shown in logarithmic scale (Fig. 3.5).

An additional normalized seasonal factor (NSF) of biota component was introduced based on expert assessments or each season to account for seasonal quantitative differences in the distribution of hydrocoles and more accurate comparison of the White Sea sensitivity between the seasons. NSF reflects the ratio of the number (biomass) of each group of hydrocoles between the seasons and is normalized so that the sum of the seasonal factors for each component is equal to the same conventional numerical value for a year (in this case this is 500, Table 3.10).

Table 3.10. Normalized seasonal factors for the comparison of integrated sensitivity of the White Sea between the seasons (including expert assessments)

Ecosystem component	Normalized seasonal factors (NSF)			
	Winter	Spring	Summer	Autumn
Phytoplankton	4	384	77	35
Zooplankton	5	124	247	124

Ichthyoplankton		30	270	190	10
Benthos		120	120	140	120
Ichthyofauna (main fish groups)	**pelagic**	62	62	42	42
	ground	62	62	42	42
	migrating	21	21	21	21
Marine mammals		450	30	20	10
Avifauna		4	194	86	216

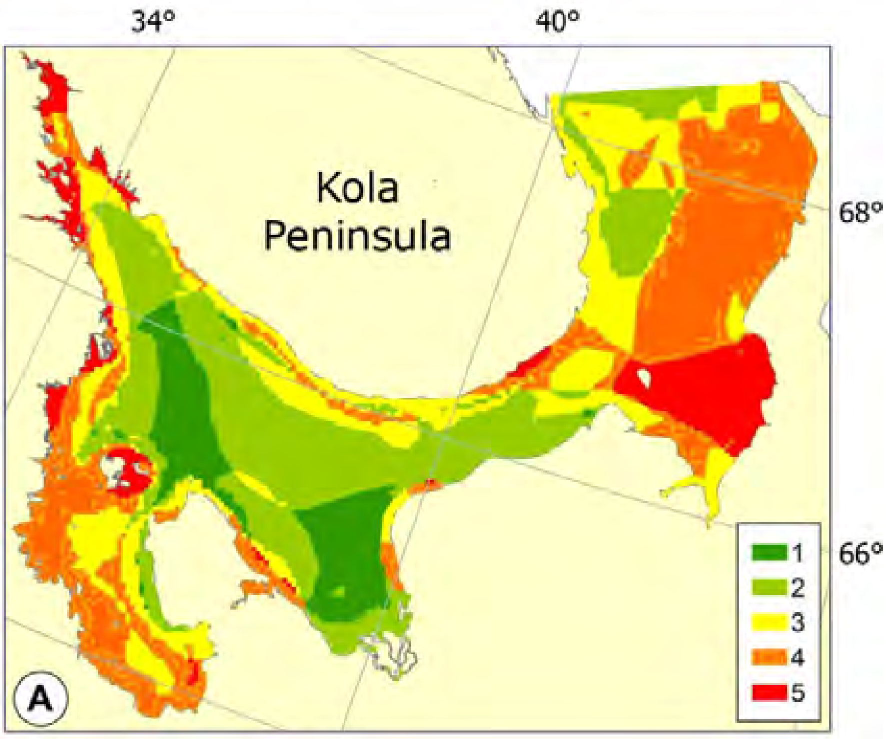
Thus, by multiplying the coefficients of the relative sensitivity of key ecosystem components (W, Table 3.1., Column 4) with the normalized seasonal factors for these components (NSF, table 3.10), the coefficients to compare the integral sensitivity of the White Sea parts between the seasons were obtained (Table 3.11).

Table 3.11. The product of the normalized seasonal factors NSF (Table 3.10) and coefficients of the relative sensitivity W (Table 3.1) to compare the integral sensitivity of the White Sea parts between the seasons

Ecosystem component		W · NSF			
		Winter	Spring	Summer	Autumn
Phytoplankton		172	16 512	3 311	1 505
Zooplankton		265	6 572	13 091	6 572
Ichthyoplankton		1 890	17 010	11 970	630
Benthos*		2 880	2 880	3 360	2 880
Ichthyofauna (main fish groups)	**pelagic**	1 178	1 178	798	798
	ground	1 178	1 178	798	798
	migrating	399	399	399	399
Marine mammals		2700	180	120	60
Avifauna		252	12 222	5 418	13 608

As a result, the maps of "relative" integrated sensitivity of the White Sea, taking into account seasonal differences in the quantitative distribution of hydrocoles, for selected seasons were made (Fig. 3.6). The coefficients of table 3.11 were used in the program for calculation.

These maps shall be arranged in the same rank scale with the same numerical values of the limits of rank intervals in order to illustrate a comparison of seasonal differences. For this purpose and for all four seasons the maps with the scale of integrated sensitivity, divided into five equal intervals from the minimum value of gridcode 6 025 (in winter) to a maximum 198 328 (in spring) were made (Fig. 3.7, Table. 3.13).



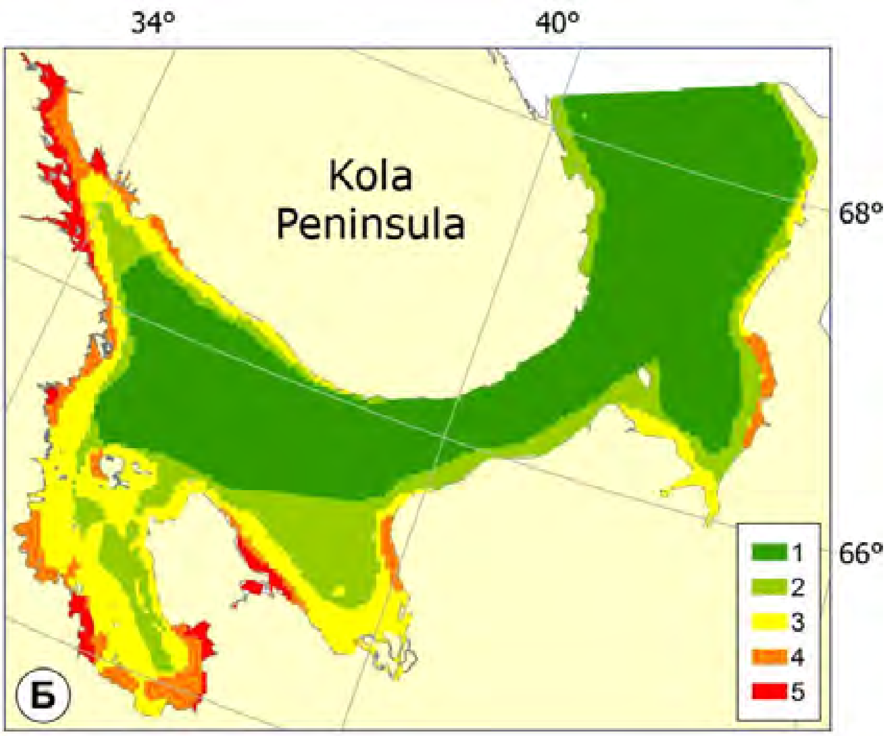


Fig. 3.6 Start. Maps of "relative" integrated sensitivity of the White Sea in different seasons, taking into account seasonal differences in quantitative factors of the hydrocoles distribution: А – Winter, Б – Spring, В - Summer, Г - Autumn. The initial distribution of the seven components of the ecosystem is taken into account (see formula 3.1). The entire range for a season is evenly divided into 5 equal intervals (5 ranks). Coefficients W from Table 3.11 were used; the cell size is 3000 m.

minimum sensitivity

maximum sensitivity

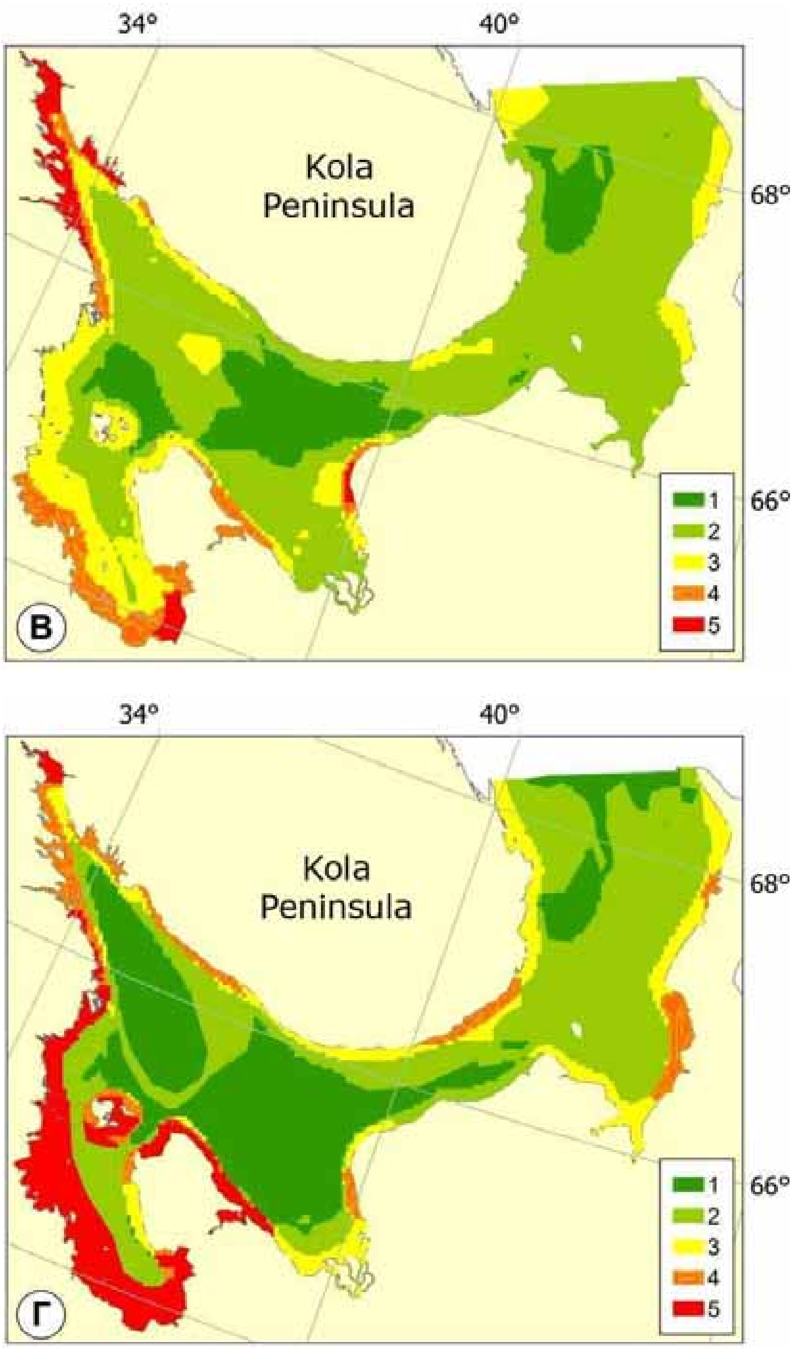


Fig. 3.6 End.

minimum sensitivity

maximum sensitivity

Table 3.12. The results of the classification statistic of the map cells in Fig. 3.6 (in conventional units of IS)

Season	Average	Standard deviation	Max value	Min value
Winter	19 874	5 621	31 879	6 025
Spring	109 606	35 092	198 328	41 246
Summer	68 755	19 131	127 835	26 673
Autumn	49 585	14 997	78 337	20 469

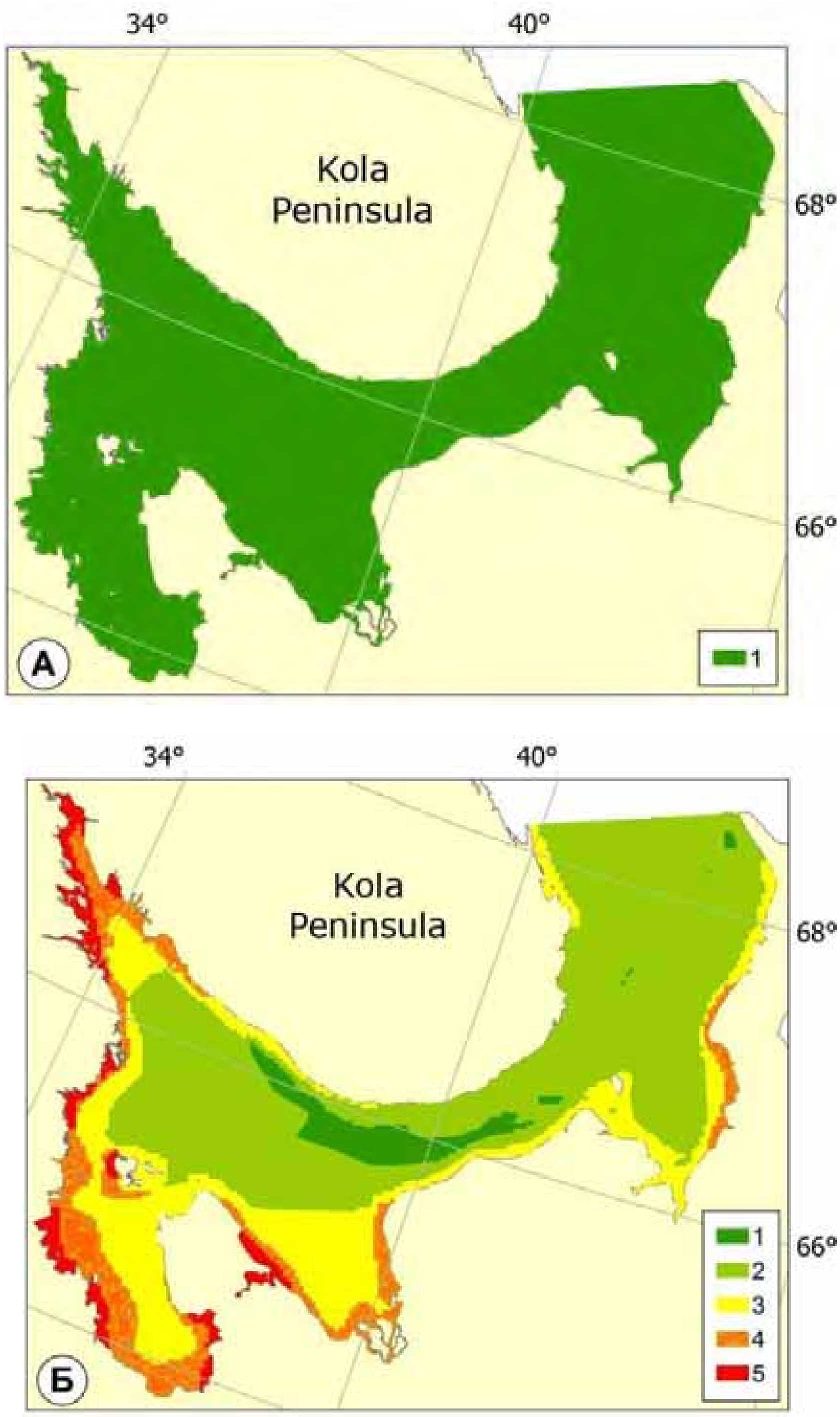
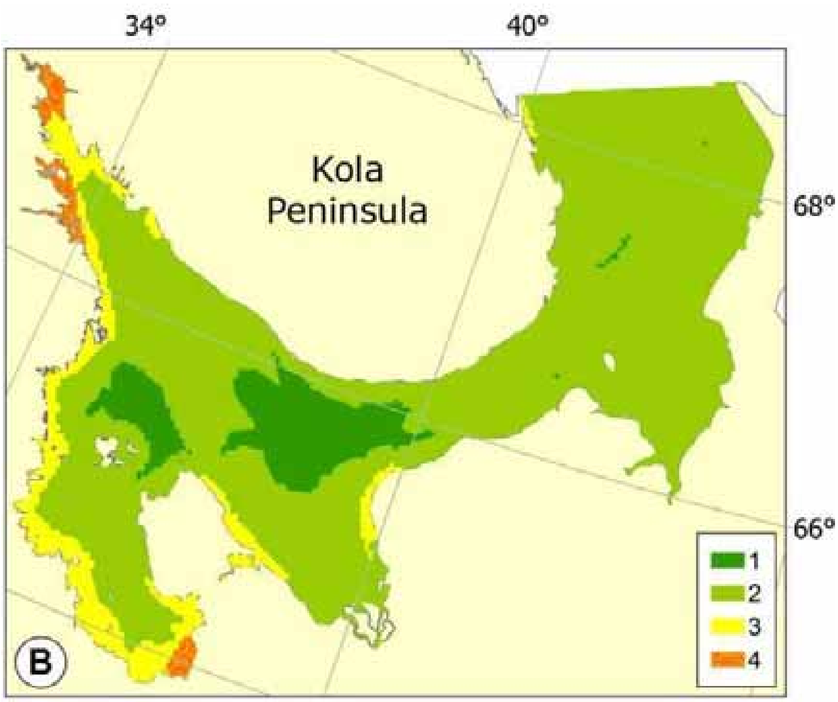


Fig. 3.7 Start. Maps of "absolute" integrated sensitivity of the White Sea in different seasons, taking into account seasonal differences in quantitative factors of the hydrocoles distribution: A – Winter, Б – Spring, В - Summer, Г - Autumn. Equal scale values intervals of IS ranking were used for all seasons in the range from 6 025 (min. for winter) to 198 328 (max. for spring). Coefficients W from Table 3.11 were used; the cell size is 3000 m.

minimum sensitivity

maximum sensitivity



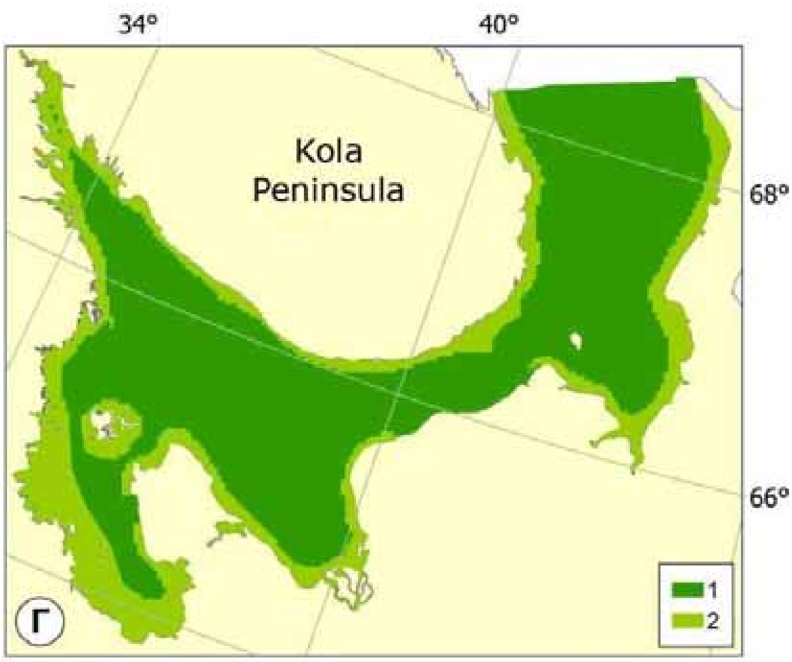


Figure 3.7 End

minimum sensitivity

maximum sensitivity

Table 3.13. The results of the classification statistic of the map cells in Fig. 3.7 (in conventional units of IS)

Season	Average	Standard deviation	Max value	Min value
Winter	19 874	5 621	31 879	6 025
Spring	109 606	35 092	198 328	41 246

Summer	68 755	19 131	127 835	26 673
Autumn	49 585	14 997	78 337	20 469

The obtained maps of the integrated sensitivity of the White Sea for different seasons (Fig. 3.6, 3.7) help to make following conclusions. The most vulnerable areas, as well as in the Barents Sea, are the coasts during all seasons. Mainly, it is the west coast of the White Sea from the Kandalaksha to Onega Bay.

The spring season is the most sensitive, but subject to the values of standard deviation (Table 3.12) it is little different statistically in sensitivity from the summer season. In relation to spring and summer, autumn is significantly less vulnerable. The least sensitive season is winter (Table 3.12)

3.4 Recommendations for the Oil Spill Sensitivity (Vulnerability) Maps Generation for the Coastal Areas

3.4.1. Seasonal time limits. It shall be noted that the sensitivity maps listed in this section are made for the four seasons that do not fully reflect the real situation at more stringent approach. For example, we can not absolutely allege that spring comes in the second quarter of the year in the whole analyzed water area of the Barents Sea or that the period from January to March is winter. According to climatic parameters winter duration in the Barents Sea is 6 months (from November to April), and the hydrological winter lasts for 5 months (from December to April), and the biological summer lasts by various estimations from one (Несветова, 2002), up to three months (Биологический атлас ..., 2000). This is the reason in particular why the results, i.e. maps of sensitivity of the Barents Sea, is rather conventional. More detailed information that would show the true boundaries of the seasons for each small area (see the subsection 3.4 and subsection 3.5) is needed to use the sensitivity maps for the purpose of oil spill responses. It is quite possible, since the operational and, moreover, tactical maps cover small areas of the coast and adjacent waters (see Fig. 3.8). The same applies fully to the maps of sensitivity of the White Sea.

3.4.2. Selection of the approach to the assessment of sensitivity of individual groups of hydrocoles and areas of the sea. An average assessment of sensitivity of hydrocoles to the averaged oil effect was applied in this report (averaged oil type includes to some extent the negative impact of all types of oil, from ultralight to heavy). Sensitivity is defined only by biomass (number) and the coefficient of relative sensitivity. However, it is obvious that fully correct method of sensitivity assessment shall be based on a real sensitivity of biota, water areas and coastal waters. For example, light oil can completely evaporate quickly and will have an impact only on sea birds and have no impact on benthos. At the same time, black oil or other heavy oil in a certain period of time (very short if water column contains too much suspensions) can submerge into the water and cause the greatest harm to benthos in shallow waters, but the impact of sunken oil on birds may be insignificant. Such approaches already exist, when the sensitivity of both biota and the mapped area is determined by the potential impact, sensitivity and recoverability (SafetyAtSea, 2007). Such technique was proposed by Dutch experts, but due to the complexity of individual stages it was not implemented, and it is not used in the Netherlands in full. The development of such techniques in Russia is based on the experience of Dutch specialists (including methods which are not overdesigned but give an adequate picture of sensitivity) requires a certain amount of time and financial costs. Brief description of this methodology is provided in subsection 3.5.

3.4.3. Necessity to register the coasts, coastal areas and the entire area of the sea in some cases. Sensitivity maps shall be made not only for the shoreline (Sensitivity. .., 1996) or the narrow coastal strip. Thus, there is a potential danger to many groups of hydrocoles for the whole shallow Onega Bay (mainly benthos and birds). Even the White Sea deep-water areas shall be taken into account for the period when the Greenland seal whelp on the ice (the central regions of the White Sea and Gorlo Strait of the White Sea). The areas located near the ice fields shall be especially taken into consideration (central part of the Barents Sea) in spring, when birds migrate from the west to the Novaya Zemlya area: birds stop in the near-edge areas and the risk of death during this period in case of oil spills is very high.

3.4.4. Recommendations of international organizations. Maps of sensitivity of sea areas to oil pollution are fairly widespread within the world practice (Sensitivity. .., 1996). The guidelines for environmental sensitivity (vulnerability) maps of the seas have been proposed by various organizations. Main provisions of environmentally sensitive areas mapping can be summarized as follows:

3.4.4.1. Vizualization of maps. Maps shall provide clear and visual information to the persons responsible for the spill response. They shall immediately inform and shall not require too much specialized knowledge to understand such information. The scale used for the maps must ensure the required accuracy of data contained and include a map of the area to establish a link between the local site and the whole area.

3.4.4.2 Self-descriptiveness of maps. Environmental sensitivity maps shall contain a comprehensive characterization of the structure of the coastline and its morphological features expressed by the index of sensitivity to oil spills, as well as biological diversity, productivity and economic objects of coastal and marine areas. It is necessary to distinguish between information on sensitive resources (eg. location of fish hatcheries and bird colonies), and practical information on spill response and clean-up of the coast (eg. areas of dispersants utilization or prohibition, placing of booms and access roads to the coast) . These are two different types of information that can be displayed on different maps and/or described in different sections of any accompanying text (Sensitivity ..., 1996).

3.4.4.3. Format of maps. It is recommended to make black and white maps in A4 format to allow copying and transmission by fax. Different types of coast shall be marked by symbols. Symbols of general purpose shall be used, which do not create controversy and which are not misleading. A large number of symbols (for example, different kinds of fish) are not recommended for sensitivity maps; they shall be placed in more detailed resource maps.

3.4.4.4. Additional features. Practical information important in terms of spill response (areas where the use of dispersants is allowed or prohibited etc.) shall be coordinated between relevant environmental organizations, before applying to the map.

3.4.4.5. Selection of scale for maps. In accordance with the multilevel approach to spill response plans (Sensitivity ..., 1996) the following set of maps is required:
- Large-scale maps of the first level (tactical maps), scale 1:25 000 (1:50 000);
- Medium-scale maps of the second level (operational maps), scale 1:250 000;
- Small-scale maps of the third level (strategic maps), scale 1:2 500 000.

Thus, the maps of coastal areas special sensitivity to the spills shall be developed in three scales and application of the relevant information for each scale.

Content and development of small-scale maps. These maps are intended to be a base map of the whole sea area and shall include an outline of the shoreline, depth contours, contour line, the position of the ice edge, reflect hydrological conditions and fishing areas, migration routes of marine biota. Maps of such scale shall show the main routes of transportation of oil and petroleum products, existing and planned terminals and pipelines.

At the first phase of work small-scale maps for the four biological seasons (not calendar) shall be made. In the future it is essential to make maps by months, perhaps not for the whole sea areas, but for the most sensitive areas. But these maps must be supplemented with information about the types of beaches and the most sensitive coastal areas (quite general, as larger scale maps are used to obtain detailed information).

If 4-6 small-scale maps are enough for the entire area of the sea, then for the coastal marine area and the shoreline requires preparation of a series of medium-scale maps (for the Kola Peninsula, Novaya Zemlya archipelago, Vaigach and Kolguev islands on the example of the Barents Sea) and detailed large scale maps (for coastal area of Murmansk and the Pechora Sea) in connection with high concentration of vulnerable targets and high risk of oil and oil products spills. Fig. 3.8 is an example of the recommended set of maps for the Barents Sea.

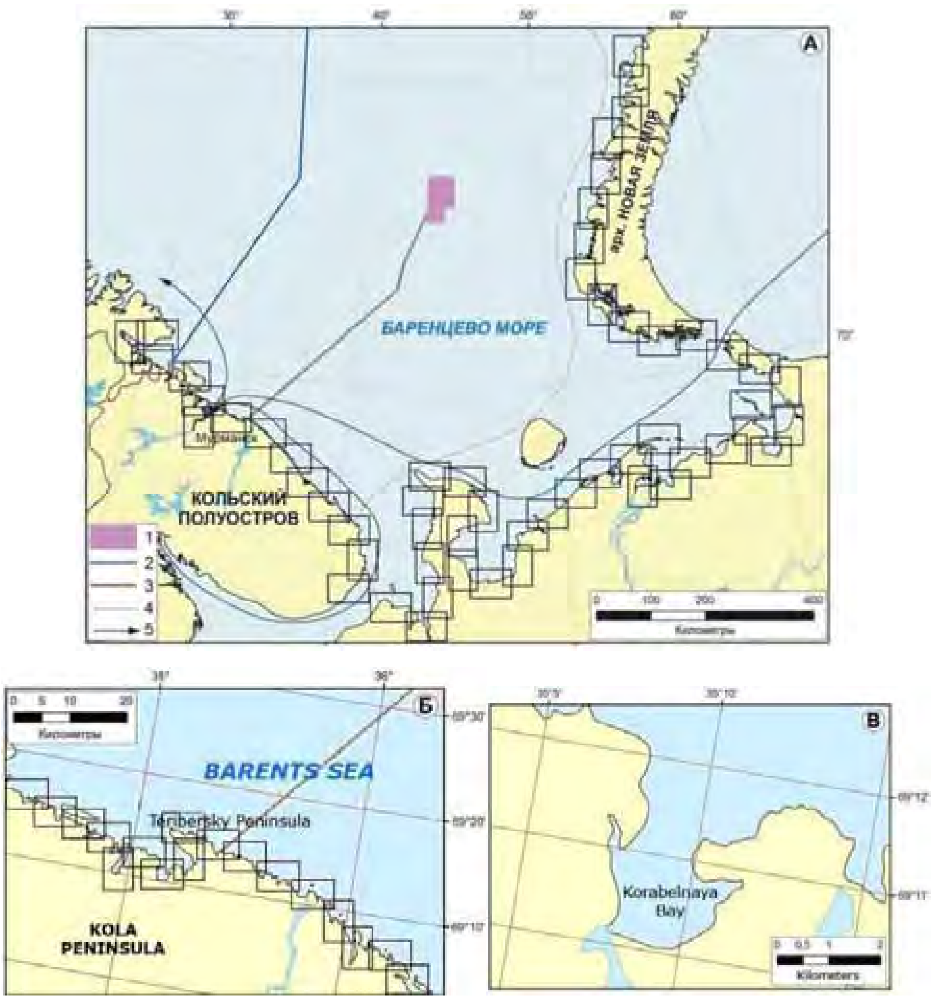


Fig. 3.8. Recommended set of maps for the Barents Sea and its littoral zone and shoreline: A – small (1:100 000), Б – Medium (1:5 000), В - a large scale (1:500), 1 – Shtokman licensed area, 2 – Delimitation of maritime delimitation and cooperation in the Barents Sea and the Arctic Ocean as of the 15th of September 2010, 3 - route of the planned pipeline from the Shtokman gas condensate field to the landfall, 4 - boundary of the average annual distribution of the ice edge, 5 - routes of oil transportation through the Barents Sea.

Content and development of medium- and large-scale maps. Such maps shall:

- reflect the types of banks showing environmental sensitivity index (ESI). It is recommended to use indices of environmental sensitivity of coasts ranged from 1 to 10 to oil pollution, proposed in 1978 by E. Gundlach and M. Hayes (Gundlach, Hayes, 1978). Indices of sensitivity must be adapted to the conditions of the Arctic region. In order to do this not just a literature review but detailed field studies (both offshore and onshore) shall be carried out.

- show the biological productivity of coastal waters and shoreline, as well as habitats and migration routes of birds and marine mammals, protected areas, important bird area and laidas. In addition, coast and the shoreline at these maps shall be ranked according to the sensitivity in terms of concentration of biota on shore.

- contain objects of economic nature management (port facilities, naval facilities, maintenance bases, transshipment complexes, industrial facilities, businesses, and mari-aquaculture etc.), recreational resources, places of cultural, historic and scientific value onshore and near shoreline. These maps shall indicate the access roads and coastal infrastructure for the line of 1-2 km in detail (on the large-scale maps) and up to 20-50 km in a general way (for medium-sized maps), as well as the boundary of the water protection zone of the Barents and White seas in the Murmansk region (500 m width).

- Show habitat below the tidal zone (topsoil bottom of littoral and sublittoral zones, a layer of brown algae that grow on the bottom of some coastal cliffs). Zones of coastal fishing in shallow waters (including crab, shrimp, etc.), places of seaweed gathering, shellfish banks in the intertidal zone or in shallow water off the coast, areas of fish and shellfish breeding, the rivers falling into the sea (important for salmon migration), etc shall also be marked.

- indicate areas (for practical purposes of spill response), where dispersants are allowed, and where they should not be used, where it is possible to deploy booms and places of permanent booms storage. "Sacrificial zones", characterized by low vulnerability shall be shown, which could be used, if necessary, to send an oil slick for the salvation of areas of high ecological sensitivity (vulnerability), and places with access roads.

3.5 Proposals to Improve Methods of Mapping the Sensitivity of the Seas and Coasts to Oil Pollution

This proposal is based on the developments of Dutch experts (SafetyAtSea, 2007) and consider the Russian experience. Below is a brief (summary) description of basic provisions of the new methodology draft.

3.5.1 Definitions

Integrated environmental vulnerability, V-vulnerability (SafetyAtSea, 2007; Lahr, 2007) is a value reflecting the extend of the damage or disturbance of biota (species, species group, community ...) and of critical areas - CA (in the water area, at the bottom, onshore ...) for a certain period of time due to any stress factors (i.e. the influence of oil). It is calculated as:

$$V_{\Sigma} = \left[\begin{array}{c} \text{Full} \\ \text{Relative} \\ \text{Sensitivity} \\ \text{of biota} \end{array} \right] \times \left[\begin{array}{c} \text{Full} \\ \text{Relative} \\ \text{Sensitivity} \\ \text{of the site} \end{array} \right] \qquad (3.2)$$

Multipliers in formula (3.2) are determined primarily by *vulnerability of certain species of biota* - (bV) and the *vulnerability of certain critical* areas (particulars) - (pv), which is directly proportional to their sensitivity (S-sensitivity), potential impact (E - exposure) and inversely proportional to recoverability (R - recoverability):

$$bV = \frac{bE \times bS}{bR} \quad (3.3)$$

$$pV = \frac{pE \times pS}{pR} \quad (3.4)$$

Potential impact on biota (bE) is a potential impact on biota by the oil when it spills (eg. potential impact on benthos by light oil at considerable depths is practically zero, since the light oil will evaporate faster than it reaches the bottom, and at the same time, heavy oil at shallow depths will significantly impact benthic community, as it will most likely reach the bottom).

Sensitivity of biota (bS) depends on the toxicological and other kinds of oil influence on the organism. Sensitivity is the degree which a species is influenced by in respect of growth, survival, reproduction by stress factors (oil effect).

Toxicological sensitivity of an organism to contaminant is usually expressed as the effective concentration or dose (similar LC_{50}, LD_{50} values) and is an absolute, species-specific characteristic (the specific characteristic of the species). This technique determines sensitivity to oil by taking into account expert assessments for each region, using a relative scale from more to less sensitive area.

The resilience of biota (bR) is the ability to recover, the ability of a community, population or species to return to a viable state, close to that which was observed before the oil pollution that caused the change.

Similar definitions by key parameters are given for critical areas, water areas and shores. Especially *critical areas* (ECA) of the mapped area refer to "*sensitive*" to oil spill sites, such as: specially protected areas, recreational areas, areas of sea or onshore industry, fishing zones. Moreover we put "*sensitive*" in brackets in this case, because we consider such a "*sensitivity*" to be purely conventional, as the degree of potential harm caused by oil to this site.

Potential impact on *especially critical areas* (pE) is a potential impact on a certain site, territory or coast caused by oil spills. For example, the potential impact of oil on a rocky almost vertical shore with small crevices is significantly less than that on a sandy beach.

Recoverability of critical areas (pR), the possibility of their recovery is the ability of the site to return to a state close to the condition observed prior to the impact of an oil spill. Otherwise, this parameter defined by the period of time a landplot on the coast or on the bottom can be cleansed of oil and return to its original state.

"Sensitivity" of the especially critical areas (pS) is the significance of this place for ecosystem or humans. Thus, SPAs are the most "sensitive", as well as recreation areas. But at the same time "sensitivity" of reserves is higher than that of the preserves, and even higher than of the national parks.

Vulnerability is not the same as environmental risks. Acepting the approach outlined in (SafetyAtSea, 2007), the *vulnerability* is a degree of possible adverse effects on biota or habitat from the effect of certain stress factors, in case such stress occurs. *Vulnerability* allows for sensitivity, exposure and potential recovery. *Risk* is a potential of adverse effects, multiplied by the consequences of this phenomenon. Habitat and/or species community are at risk in case an external factor applies or may apply (in the absence of navigation and the output of oil from the bottom or shore, species vulnerable to oil spill will never be at risk) (SafetyAtSea, 2007).

3.5.2 Main Development Stages of Integral Sensitivity Maps of Marine and Coastal Areas

The sequence of sensitivity maps generation includes the following four steps:

Step I. Preliminary plan

1.1. Determination of the mapped area boundaries. Generation base maps of different scales for this area in a unified and justified map projection (tactical maps: scale - 1: 10 000 - 1: 25 000 operating - 1: 100 000 - 1: 200 000, strategic - 1: 1 000 000 - 1: 2,500,000). Preparation of brief description of the physiographic features of the area mapped.

1.2. Classification of oil and oil behavior in seawater, the assessment of possible appearance of oil in the mapped area (if tankers carry only light oil, and there are fishing and cargo vessels that use diesel fuel in the area, heavy oil may not be considered and sensitivity maps may not be generated).

1.3. Delimitation of the seasons the maps are made for (first, second, third, fourth seasons, and the number of periods/seasons the whole year is divided into, not necessarily to be four). Preparation of brief description of ecosystems of the mapped area.

Step II. Preparation of initial normalized maps of the biotic components of the area

2.1. Selection of the most important and significant biotic components of the ecosystem (the following groups of hydrocoles are considered: macrophytobenthos, zoobenthos, ichthyoplankton, fish, marine mammals, sea and water birds; phytoplankton and zooplankton are generally not considered). Based on these components sensitivity maps will be built; determination of significance (bT) of the biotic components for the ecosystem.

2.2. Generation of seasonal distribution maps of species and groups of hydrocoles in the mapped area (this mapping is made in the units adopted for the species or species groups: in g/m^2, mg / dm^3, t/h of trawling etc.).

The normalization of the biota distribution maps.

2.3. Expert evaluation of the parameters that determine the vulnerability of the selected biotic components and, if necessary, certain types of biota: the potential impact (bE), sensitivity (bS), the index of recoverability (bR)

2.4. Calculation of vulnerability of the selected biotic components of ecosystems (bV) from oil by formula (3.3).

Step III. Preparation of initial normalized maps of especially critical areas of the mapped area

3.1. Selection of critical areas in the mapped area - specially protected areas, areas important from an environmental point of view, but not designated as specially protected areas, recreational areas, areas with industrial facilities

3.2. Generation of maps with the boundaries of especially critical areas. Normalization of ECA maps.

3.3. Expert evaluation of values that determine the vulnerability of selected critical areas (p - particular - special): the potential impact (pE), «sensitivity» (pS), recoverability (pR).

3.4 Calculation of "vulnerability» (pV) from oil of such critical areas (by formula (3.4).

Step IV. Generation of oil spill sensitivity maps for a selected area

4.1. Generation of seasonal sensitivity maps for biota.

4.2. Generation of ECA sensitivity maps.

4.3. Generation of seasonal integral sensitivity maps of the mapped area by formula (3.2) based on the biota and ECA sensitivity maps.

4 STUDY OF THE PROPERTIES OF THE MAIN OIL TYPES TRANSPORTED THROUGH THE BARENTS AND THE WHITE SEAS AND DETERMINATION OF THEIR BEHAVIOR ON THE WATER SURFACE IN VARIOUS HYDROMETEOROLOGIC CONDITIONS

4.1 Export of Russian Oil[12] via Oil Terminals of Northern Seas of Russia and Main Sea Routes of Oil Transportation in the Barents and the White Seas

4.1.1 The Barents Sea Route of the Russian Hydrocarbons Export

Taking into account the growing demand of foreign markets for energy resources a need for expansion of the RF transportation capacities has emerged. The insufficient capacities of the pipeline system for the Russian oil export has urged the large oil companies to look for the possibilities of hydrocarbon shipment abroad via the navigational routes of the Barents Sea (the Barents Sea Route)

Today the Barents Sea Route is a part of the common transport system of North-West Russia and the development of export in the Barents Sea Route is one of the main provisions of the transport doctrine of Russia.

The development of the Barents Sea Rote allows direct export of oil by sea from the production fields of NWFD (Varandey, Kolguev Island), West Siberia (Numgi, Andra) and East Siberia (Dudinka) as well as the railway oil transportation from the European and Asian parts of Russia (Privolzhsky, Central and North-West Federal Districts) to the ports of the White and the Barents Seas for further shipment by sea (Григорьев, 2006).

The Barents Sea Route and the Northern Sea Route (NSR) are beginning to play an important role in oil export for the markets of South-East Asia. The Russian oil shipping along the Barents Sea Route has the following advantages:

- It solves the problem of shipping the raw materials produced in North-West Russia from the fields on the islands and coast of the Pechora Sea, in the basins of the Ob, the Yenisei, and the Lena Rivers, and provides the export transit for the oil produced in the central parts of Russia;
- Allows considerable diversification of the transport delivery plans and gives free choice to the foreign consumers of the Russian oil;
- Considerably reduces the capital costs for oil transportation as compared to the pipeline transportation;
- Oil transportation via the Barents Sea can be carried out by vessels of any deadweight;

The Barents Sea Route transportation plan includes three delivery options – the main pipeline (MP), the railway and direct shipment by sea from the production field.

The most common transportation plan for the Barents Sea Route implies that the oil is delivered from the production field through the MP system to transshipment facilities, then it is loaded into railway tanks and delivered to the sea terminals of the White and the Kara Sea where it is loaded into shuttle tankers which deliver it to the storage tankers in the Kola Bay, the Barents Sea, from where it is shipped by the line tankers of

[12] Hereinafter "oil" means all kinds of crude oil, light and dark petroleum products and gas condensate.

larger deadweight. In terms of transshipment quantities, the ports and terminals of the White Sea play the crucial role in the structure of oil transportation to the Kola Bay (fig.4.2.).

The following oil flows meet in the Barents Sea: (fig. 4.1.):

- From the production fields of the Timano-Pechora and West Siberia oil-and-gas provinces (OGP) – delivered by rail to the stations White Sea and Privodino and shipped from the Port Vitino and Arkhangelsk (the White Sea) by tankers to the port of Murmansk for transshipment and directly for export;
- From the production fields of Timano-Pechora OGP – delivered by tankers via the sea terminals of the Varanday Port and the Kolguyev Island for transshipment and directly for export;
- From the production fields of West Siberia OGP – delivered by sea from different river terminals of Andra and Numgi to the Port of Murmansk for transshipment;
- From the Volga River Basin and Central Russia – petroleum products from refineries by rail to the stations in Kola, Murmansk and Mokhnatkina Pakhta;

Fig. 4.1. The main routes of the Russian hydrocarbons transportation along the Barents Sea Route

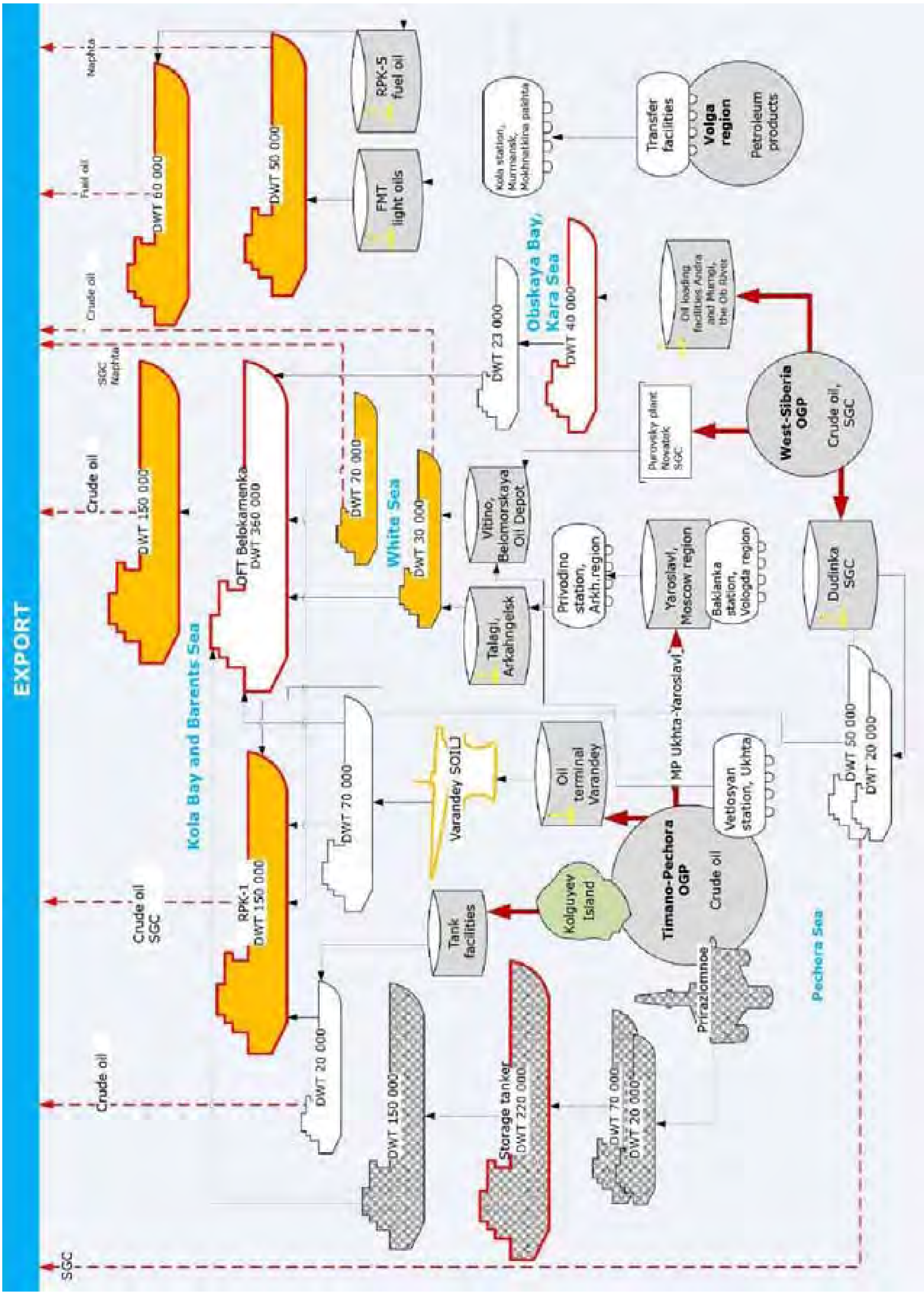


Fig. 4.2.The structure of hydrocarbons transportation though the Barents and the White Seas

The main routes of the Russian oil transportation in the Barents and the White Seas (fig.4.1) lie along the coast of the Kola Peninsula according to the established navigation routes mandatory for all vessels transporting hazardous cargos including oil cargos (Сводное описание…, 2007)

4.1.2 The Main Arctic Ports and Oil Terminals

The oil terminals and harbor transshipment facilities from which tanker oil transportation is carried out along the sea routes of the Barents and the White Seas are located in the sea ports of Murmansk, Arkhangelsk, Vitino, Varandey, Dudinka, and in the Obskaya Bay of the Kara Sea. The description of the main parameters of the Arctic oil terminals involved in shipping oil for export along the Barents Sea Route is given below.

The White Sea:

The port of Arkhangelsk and Talagi terminal
The port of Arkhangelsk has a well-developed transport infrastructure and plays an important role in energy supply to the northern territories. Crude oil from the Timano-Pechora OGP is delivered through the main pipeline system Usa-Ukhta-Yaroslavl and also by rail from the Vetlosyan station and travels through the main pipeline system Usa-Ukhta-Yaroslavl to the oil pumping station Privodino of the Northern Railways located in the south of Arkhangelsk Region 790 km away from Arkhangelsk. From Privodino crude oil is transported to the coastal terminal in Talagi located 16 km of Arkhangelsk on the White Sea coast. In Talagi the oil is loaded into 30,000-ton ice class tankers (RN Arkhangelsk, RN Murmansk, RN Privodino) and goes to the Western market mostly via the offshore transshipment facility Belokamenka RPK-3 in the Kola Bay of the Barents Sea.

The port of Vitino and Belomorskaya Oil Depot
The oil terminal of the port of Vitino is located on the south-western side of the Kandalaksha Bay, the White Sea, and uses the facilities of the Belomorskaya Oil Depot. The port of Vitino receives oil and petroleum products by rail. Crude oil is delivered from terminals of Yaroslavl and Moscow Region as well as from the oil terminal at Baklanka station in Vologda Region where it arrives through the main pipelines of OJSC Transneft. Special attention is paid to transshipment of “Ukhtinsky” oil type which is produced in the Timano-Pechora OGP. Gas condensate is delivered to the oil terminal of the Vitino sea port by rail from Purovsky plant operated by Novatek, YaNAO (Yamalo-Nenets Autonomous Okrug). The raw material is delivered to the plant from the Company’s production fields in YaNAO (West Siberia OGP) through the condensate pipeline. In the port of Vitino the oil and petroleum products are loaded into 70,000-ton ice class sea tankers which export the cargo directly or with transshipment in the Kola Bay, the Barents Sea.

The Kara Sea:

The port of Dudinka
Dudinka is the largest Siberian sea port located in the lower course of the Yenisei River. It has all-the-year-round sea connection with Arkhangelsk and Murmansk. The port of Dudinka ships gas condensate produced at the Petelinskoye production field into 20,000 – 50,000-ton tankers for export via terminals of the Barents Sea. Since September, 2009 the vessels of OJSC GMK Norilsk Nikel have started direct voyages from Dudinka to ports of Europe (Hamburg and Rotterdam).

Obskaya Bay

Crude oil produced at the Sredne-Khulymskoye and Sandybinskoye fields in Western Siberia is delivered through the local pipelines to oil-loading facilities in Andra and Numgi on the Ob River where it is loaded into river tankers, type river-sea Lenaneft tanker (deadweight 2,100 tons) and delivered downstream the river to the Obskaya Bay, the Kara Sea, to the storage tanker with a deadweight of 39,000 tons. Sea tankers such as Khatanga (23,000), Saratov (20,000) and Varzuga (16,400) transport the oil from the Obskaya Bay along the NSR via the Kara Strait to the offshore transshipment facility Belokamenka in the Kola Bay, the Barents Sea.

The Pechora Sea:

Specialized Oil Terminal and port of Varandey
The specialized oil terminal and port of Varandey operational all the year round serves for oil shipment from the northern production fields of Timano-Pechora including the fields Khylchuyuskoye, Yuzhno-Khylchuyuskoye, Yareyuskoye, Inzyreyskoye and the promising area in the northern part of the Kolvinsky megalithic bank and Khoreyverskaya Depression. Oil from these fields is transported to Varandey terminal through pipelines. The terminal includes onshore tank facilities of 325,000m^3, 22.6 km subsea pipeline and a permanent offshore ice-resistant loading jetty. The Varandey terminal loads crude oil into 70,000-ton tankers of enforced ice class and sends it for export directly or with transshipment at Belokamenka in the Kola Bay.

Kolguyev Island
Oil produced at the Peschanoozerskoye field of the Kolguyev Island is delivered through infield pipelines over a distance of 3-5 km to oil treatment plant. Then the oil is delivered to the export tank facilities 12 km from the oil production center and further is shipped for export via the offshore oil-loading jetty situated near the shore and connected to the tank facilities by the pipe subway. The export oil from the Kolguyev Island is loaded into 20,000 tankers and delivered to the storage tanker in the Kola Bay or directly to Rotterdam. The crude oil export from the island is limited both by the production output and the summer navigation period of two to six months.

Prirazlomnoye oil field
The Prirazlomnoye is one of the largest oil fields explored in the Pechora Sea. Oil production is planned with the help of offshore ice-resistant permanent platform Prirazlomnaya designed for all-the-year-round production drilling. The crude oil from Prirazlomnoye will be shipped for export and in future may be delivered to the planned refinery in the Murmansk Region. The designed structure of oil sea transportation includes two ice class shuttle tankers with a deadweight of 70,000 tons each; 1-2 ice class shuttle tankers with a deadweight of 20,000 each; a storage tanker wit a minimum deadweight of 220,000 tons; up to 4 line tankers with a deadweight from 150,000 tons. The crude oil from Prirazlomnoye is expected to be exported with transfer in the ice-free area of the Barents Sea (at Belokamenka or another terminal) or delivered to the refinery that may be built in the Murmansk Region.

The Barents Sea, the Kola Bay, the port of Murmansk:

First Murmansk Terminal, Ltd.
The onshore terminal for oil and petroleum products, First Murmansk Terminal, Ltd. was established with the use of oil depot of the Murmansk Fishing Fleet. The terminal specializes in loading light oil products to line tankers with a deadweight of 50,000 tons for export.

Oil transshipment facility, Kommandit Service, Ltd.

The terminal specializing in black oil transshipment is located on the east side of the Kola Bay north of Murmansk on cape Mokhnatkin. The facility includes an oil discharge area with two-way railroad overpasses, an oil products storage area (tank facilities), a pipeline for transfer of black oil into the storage tanker, and a 3-pontoon heavy floating mooring jetty with a set of offshore mooring equipment for the storage tanker.

Oil products are delivered by rail to the Mokhnatkina Pakhta station, loaded into the storage tanker through the pipeline and then into the sea-going tankers with a deadweight of up to 60,000 tons which deliver the cargo to the consumers including the western market.

RPK-1
The first offshore transshipment facility (RPK-1) of OJSC Murmansk Shipping Company is located in the Kola Bay near Cape Mishukov. The terminal comprises eight anchoring and mooring systems that allow receiving storage and sea-going tankers with a deadweight of up to 150,000 tons in bad weather with the wind of up to 20 m/c. Shuttle tankers with a deadweight of 15,000-60,000 tons can moor to the sea-going tankers for oil transshipment. The oil is delivered to RPK-1 by shuttle tankers from the terminals on the Kolguyev Island (20,000-ton tankers), Varandey (70,000-ton tankers) and from Vitino (70,000-ton tankers). Gas condensate is delivered from Dudinka by tankers with deadweight of 20,000-50,000 tons. At RPK-1 oil and gas condensate is reloaded into the line tankers of about 100,000 tons of deadweight and exported.

RPK-3
The biggest offshore terminal (RPK-3) Belokamenka was commissioned in 2004. It is based on the floating oil storage facility – the storage tanker Belokamenka of 360,000 tons of deadweight. RPK-3 is the central component of the export transportation structure with the help of which OJSC Rosneft implements the oil delivery chain “from well to customer”. RPK-3 is the main terminal of the Barents Sea integrating the transportation flows and capable of supporting deliveries both to the ports of North Atlantic in Europe and America and to other regions. The design of Belokamenka tanker allows handling all the arriving oil types without mixing them. The offshore facility allows accumulating and export shipping of oil arriving from three directions:

– All-the-year-round from the Arkhangelsk port;
– All-the-year-round from the Varandey port;
– Seasonally (from June 25 to September 28) from the Obskaya Bay.

In future RPK-3 Belokamenka will also receive oil from the Prirazlomnoye oil field.

4.2 Main Types of Oil Transported through the Barents and the White Seas

4.2.1 Quantities and Oil Types Shipped from January to October 2010

Over the period from 1 January 2010 to 1 October 2010 about 10 million tons of oil were shipped for export from the main Russian Arctic oil terminals. Table 4.1 shows information on each type of oil shipped for export over the above period[13].

Table 4.1. Types of oil shipped from the main Russian Arctic oil terminals in 2010

Facility	Cargo	Quantity (tons)	Destination

[13] The data are provided by Administration of Murmansk Sea Port.

Facility	Cargo	Quantity (tons)	Destination
Murmansk port:			
RPK-1	Crude oil	26 773,1	export
	Gas condensate	49 868,1	export
	Black oil	13 495,7	Domestic market
RPK-3 Belokamenka	Crude oil	5 637 331,7	export
	Black oil	10 090,0	Domestic market
RPK-5 Kommandit-Service	Black oil	810 474,4	export
First Murmansk Terminal	Black oil	36 381	Domestic market
	Diesel fuel	65 184,1	Domestic market
	Naphtha	728 403,4	export
Vitino Port	Gasoline	39 990,9	Domestic market
	Naphtha	1 111 787,5	export
	Petrol	67 628,7	Domestic market
	Gas condensate	1 729 957,1	export
	Black oil	232 833,9	Domestic market
Arkhangelsk Port	Diesel fuel	1 698	Domestic market
	Crude oil	164 588,4	export
	Black oil	33 010	Domestic market
Varandey Port	Crude oil	5 777 124,0	export
Dudinka Port	Gas condensate	62 260,4	export
Obskaya Bay	Crude oil	183 122,2	export
Kolguyev Island	Crude oil	26 726,4	export

Based on the shipment quantities (fig. 4.1) the main hydrocarbons exported through the White and Barents Sea from January to October 2010 areas follows (fig. 4.3.):

- Crude oil transported by sea along the route: Varandey – KB – Western market;
- Crude oil transported along the route: Ukhta – Yaroslavl – Arkhangelsk – KB – Western Market;
- Gas condensate transported along the route: Dudinka – the Kara Sea – KB – Western Market
- Naphtha transported along the routes: Vitino (The White Sea) – KB – Western Market; Murmansk (KB) – the Barents Sea – Western Market;
- Black oil transported along the route: Murmansk (KB) – the Barents Sea – Western Market.

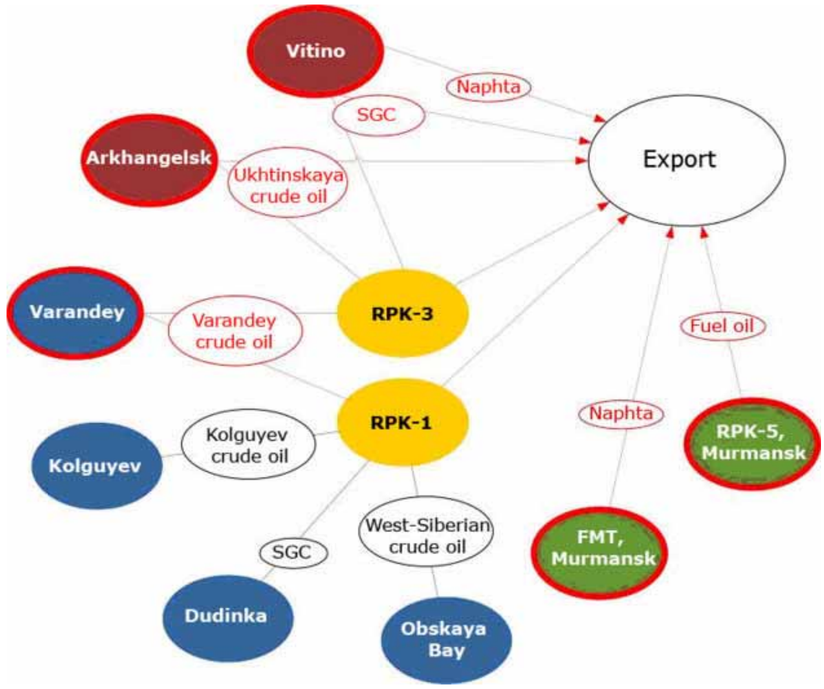


Fig.4.3. Main export hydrocarbon cargos and their transportation routes

- types of oil used for computer simulation of oil behaviour on the sea surface of the Barents and White Seas under different hydrometeorological conditions (see paragraph 4.3.4).

4.2.2 Properties of the Main Oil Types Transported Through the Barents and the White Seas

Crude oil

The main cargo flow of crude oil through the Barents and the White Seas is provided from the Timano-Pechora OGP. The weight-average parameters of all the oil produced in the area of the Timano-Pechora OGP are as follows: density: 0,855 g/cm^3, sulphur content – 0.84%. When assessing oil types the quantity and quality of the product are identified differently for railway, sea and pipeline oil production centers (OPC). Separate calculations are done for each sea and railway oil production center while oil transportation through the system of main pipelines implies confluence of oil product flows from each of oil production center as the product is flowing which results in stacking the product amounts and mixing the delivered oils. Assessment of product parameters based on the analysis of oil production structure at oil production centers' fields is shown below. (Григорьев, 2004):

- Kolguyevsky OPC (offshore). This is the best quality oil produced in the Timano-Pechora OGP (density 0.780 g/cm^3, sulphur content 0.19%). The oil is classified as extra light, low-sulphur type.
- Prirazlomny OPC (offshore). When out into operation it will produce the heaviest and the most high-sulphur oil from Timano-Pechorskaya OGP – bituminous, high-sulphur (density 0.910 g/cm^3, sulphur content 2.3%).
- Varandey OPC (offshore). Bituminous, high-sulphur oil, density 0,902 g/cm^3, sulphur content 1.98%.

There are 11 OPC's along the oil pipelines route from Ardalinskoye field of the Timano-Pechora OGP in the north to Ukhta, 10 of which are pipeline-based and 1 is railway-based. As the oil travels through the pipelines from Ardalinskoye and Khasyreyskoe fields to Usa and further through the main pipeline system to Ukhta, the oil flows from different OPC's mix; as a result in Ukhta the parameters of the commercial oil are as follows: density – 0.851 g/cm^3, sulphur – 0.82% (medium-sulphur oils). Thus, there are three oil sorts from Timano-Pechora exported to foreign markets through the Barents and the White Seas: Kolguyev, Varandey and Ukhta sorts (Григорьев, 2004) [Table 4.2]

Table 4.2. The established oil sorts from Timano-Pechora OGP

Conventional sort	Density, g/cm^3	Sulphur content, %	Type and class according to GOST 51858 Oil. General specifications
Kolguyev	0.780	0.19	Extra light low-sulphur
Varandey	0.902	1.98	Bituminous high-sulphur
Ukhta	0.851	0.82	Medium-sulphur

The largest part of the crude oil exported in 2010 via the Barents Sea terminals along the routes lying through the points selected for simulating was the Varandey sort, whereas the crude oil mostly transported via the White Sea terminals was the Ukhta sort of crude oil.

Petroleum products

Petroleum products shipped for export through the Barents Sea and the White Sea include both dark and light products transported mostly by rail from refineries in the Volga River Basin and Central Russia. The most part of light petroleum products shipped for export through the Barents and the White Seas is naphtha (stable natural gasoline), and the main type of dark petroleum products is black oil M-100.

Stable gas condensate

The Barents and the White sea terminals are used for transfer of stable gas condensate which is produced mainly at the fields of the Western Siberia OGP.

In planning OSR operations one must take into account the physical and chemical properties of the transshipped oils. The physical and chemical properties of oil transported through the Barents and the White Seas are given in Appendix D.

4.3 Simulation of Weathering of Main Sorts of Oil in Case of Potential Spills in the Barents and the White Seas

4.3.1 Oil Behavior in Case of Spill onto the Water Surface

Understanding of the processes that take place with oil on water is crucial for taking the right decision in choosing the OSR strategy and, eventually, it influences the efficiency of OSR operations. From the first seconds of contact with sea water, oil ceases to exist as the initial substance and undergo complex dynamic processes of transfer, dispersion and transformation. The main physical properties of oil that determine its behavior during a spill at sea are density, viscosity, dissolution parameters and pour point. Oil properties on water change as a result of such natural processes as evaporation and dissolution (fig. 4.4.). Oil-in-water emulsions are formed; part of oil is taken up by living organisms and sediments. Under ice conditions the intensity of these processes decreases dramatically and oil is accumulated under the ice, in its gaps and hollows remaining there until the ice melts (fig. 4.5). All these processes usually take place simultaneously but their relative importance for OSR operation changes as time goes. The main processes that take place with oil on the water surface are described below.

Drift (transfer)

Drift is changing the oil slick location under the influence of wind and currents. Usually the wind effect accounts for 3% of the wind speed while the current effect accounts for 100% of the current speed. In terms of response the drift may move towards the shore which imposes the risk of shore pollution, or it may move to the open area where the contact with the shore will be avoided. In case of oil spills in ice conditions oil is released on the ice surface, inside the ice and under the ice. The oil may be either drifting with ice or move relative to the ice under the influence of wind and current. The speed of oil moving under the ice may be influenced by the unevenness of the lower side of the ice, its porousness as well as the density and viscosity of the oil. Thus, the ice and the oil may move in different directions which must be taken into consideration when choosing the OSR method (Мерициди, 2008).

Spreading

Spreading is expansion of the oil slick on the water surface. The speed of spreading is influenced by such oil parameters as viscosity, pour point, paraffin content as well as the sea status and weather conditions. In most cases the oil spreads in a from of a film which in several hours begins breaking into stripes parallel to the direction of the wind. The stripes usually move in the same direction with the speed equal to the speed of the current. Spreading causes expansion of the slick area while the film is becoming thinner. This obstructs containment and enlarges the response zone which means that more OSR resources will be required. Under ice conditions with high ice concentration (>50%) the oil spreads between the floating blocks of ice. Under the conditions of broken ice the oil spreads less and the oil film is thicker than in case of an oil spill on ice-free water. If the ice concentration is 6-7/10, the blocks of ice considerably limit the spreading of oil. Freely drifting blocks of ice (if the ice concentration is <3/10) practically do not have any influence on oil spreading. (Мерициди, 2008).

Evaporation

Evaporation is a process that causes loss in the mass of the spilt oil and changes in its initial properties which needs to be considered when choosing an OSR technology. The speed and degree of oil evaporation is mostly determined by the presence of volatile fractions. Unstable oil types such as kerosene and gasoline may completely evaporate within several hours of the spill; light crude oil may evaporate by 40% within the first 24 hours. Heavy crude and black oil evaporate more slowly. The speed of evaporation depends on the speed of spreading, sea status and the weather conditions. The spreading area, the strength of wind and waves, higher temperature – they all accelerate evaporation. Evaporation reduces the amount of oil but it increases its viscosity and density, and the probability that the oil will sink increases, too (Sydnes, 1985). In case of abundant evaporation of light oils such as stable gas condensate or petrol a risk of fire or explosion emerges which needs to be considered during OSR operations. Under ice conditions due to lower temperatures of water and ambient air the speed of oil evaporation is usually lower than that under ice-free water conditions (Мерициди, 2008).

Dispersion

Dispersion is a process of oil drops transfer from the sea surface into the water column under the influence of waves. Separate oil drops are more available for uptake by marine organisms which accelerates the processes of biological oil decomposition. The dispersion speed depends on the oil properties, the thickness of the slick and the sea status. Oil that remains liquid and spreads freely may be completely dispersed under the moderate waves within several days. Dispersion of viscous oils and oil emulsions is very limited. High degree of oil dispersion in shallow water may cause acute intoxication of the aquatic life due to penetration of large amounts of oil, including its toxic fractions, into the water column. In the open sea at large depths water dispersion has a much lower negative effect (Мерициди, 2008).

Emulsification

After rough sea conditions in the oil spill area in case of high concentration of non-volatile components the oil-iand-water emulsion forms, that is a mixture of water and oil that practically do not enter into reaction. One of the substances is mixed into the other by way of small drops. The most stable emulsions are those of “water in oil” type (also known as “chocolate mouse” because of the brown color) that contain up to 80% of water and may drift at sea for several months. Oil-and-water emulsions are very stable which obstructs decomposition processes. Water absorption increases the initial amount of spill, changes the density and the oil flash point. This needs to be considered when estimating the OSR resources, time for OSR operation, and tanks for collection and temporary storage of the collected oil (Мерициди, 2008).

Dissolution

Dissolution is a physical and chemical process of hydrocarbons mass transfer from the oil film into the water column. Oil dissolution in water is usually insignificant and mostly involves only the lighter components. This process rarely has any importance for oil recovery from the sea surface. (Мерициди, 2008).

Oxidizing

Oxidizing is the change in oil hydrocarbons’ composition under the influence of the sunlight. The interaction between hydrocarbons and oxygen forms either dissoluble products or firm tar. The sunlight may facilitate the oxidizing process but generally the oxidizing effect is minimal compared to the influence of other natural processes (Мерициди, 2008).

Biological decomposition (biodegradation)

Transformation and degradation of oil as a result of microorganisms’ life activity eventually determine the fate of most oil substances in the marine environment. About 100 bacteria and fungi are known to be able to use oil components as material for their own growth and development (Atlas, 1993). The major factors that have influence on the speed of oil biodegradation are the temperature of the environment as well as availability of oxygen and nutrients.

Sedimentation

The presence of suspended particles of various composition and origin in the marine environment causes part of oil (up to 10-30%) to be absorbed by the suspended matter and to settle on the seabed. These processes mostly take place in the narrow near-shore zone and in shallow waters where suspended matter is abundant and the water is exposed to intensive mixing. In deeper water and in areas more remote from shore oil sedimentation is very slow except for heavy oils (Патин, 1997).

Sticking and freeze-in (ice conditions)

In case of oil spill under ice conditions oil sticking to the ice takes place. Sticking on the lower, more porous ice surface is more intensive than that on the even and smooth upper surface. The sticking process progresses quickly if the ice surface is covered with snow; in this case oil and snow form viscous mass that considerably obstructs the process of oil collection. On the lower side new ice layers build-up which may cause oil freezing-in in the ice field. As the ice melts on the upper surface and forms in the lower layers the oil will move upward and eventually will come on the surface through the ice cracks. (Мерициди, 2008).

Oil onshore

Oil on an open surface of the shore unprotected from waves and wind may completely weather off within quite a short period of time. Oil that has soaked into the shore sediments and protected from most of natural degradation processes decomposes very slowly and, periodically leaking onto the surface, may cause permanent pollution of the environment. Under ice conditions oil may freeze-in into the ice as land fast ice forms or may be sprayed on the ice surface. (Руководство…,2002).

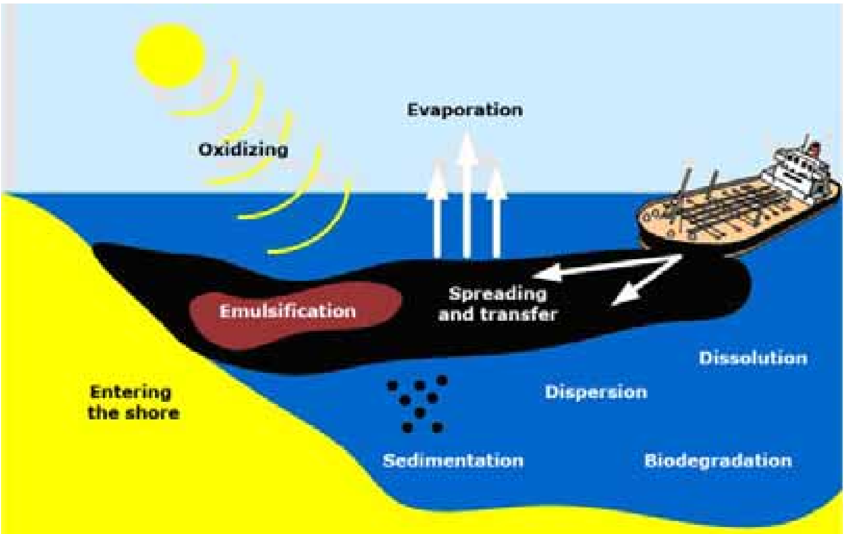


Fig. 4.4. Oil weathering on ice-free water

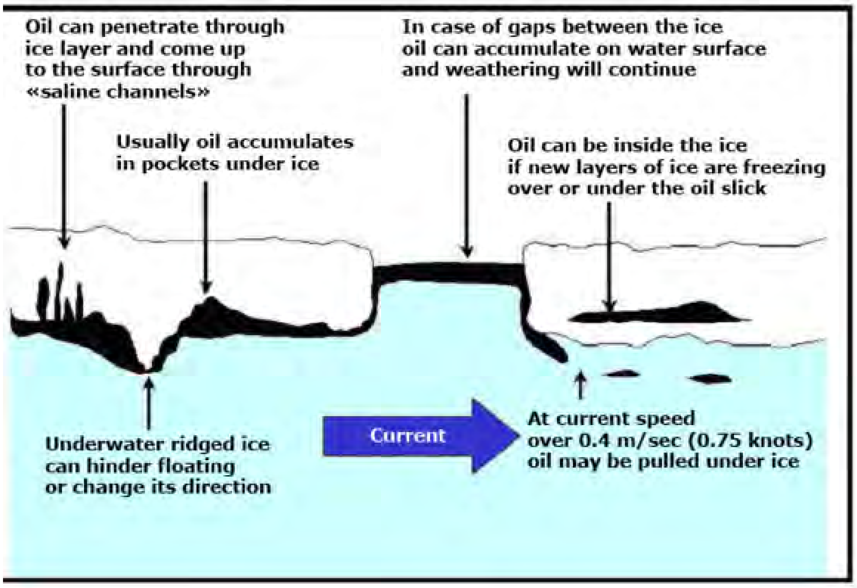


Fig. 4.5. Oil weathering under ice conditions (Руководство…, 2002)

4.3.2 Justification of Selection of Potential Oil Spill Locations

For the purpose of weathering studies of oil spilt on the water surface in the Barents and the White Seas in various hydro-meteorological conditions this study contains the computer simulation of possible oil spill (OS) scenarios.

Computer simulation of weathering of different oil types on the water surface of the Barents and the White Seas in various hydro-meteorological conditions is carried out with the help of electronic program PICSES II developed by Transas, which is a simulator for emergency exercise and is used for training and instruction of personnel and management of the interacting forces in simulated emergency situations, such as OS. In order to perform computer simulating the following basic data are input into the programme:

- Oil spill location;
- Oil characteristics;
- Volume of oil spilt;
- Hydro-meteorological characteristics of oil spill location area.

The simulation was carried out taking into consideration all the main oil types that were exported through the White and the Barents Seas from January to October 2010 (table 4.1). For simulation of various OS scenarios an OS location in the Barents Sea and an OS location in the White Sea were selected. The selection of OS locations for simulation was based on the following criteria:

- The OS location is situated at the crossroads of the main navigation routes in the Barents/White Seas where all the oil types specified in Table 4.1 are transported;
- The area of OS location is dangerous in terms of navigation;
- The OS location is situated near the shore areas highly sensitive to oil spills.

The analysis of the main navigation routes and dangerous navigation areas in the Barents and the White Seas was done based on the provisions of Navigation Regulations in the Barents and the White Seas (Сводное описание…, 2007) and pilot charts (Лоция

Баренцева моря, 1995; Лоция Белого моря, 1983). As the result of this analysis the two most dangerous navigation areas were identified in the Barents and the White Seas. These areas are limited by the lines connecting the following coordinates:

Area 1. the Barents Sea (fig. 4.6.):

1)	69°17,94'N,	33°32,62'E;
2)	69 19,00	33 30,15
3)	69 20,67	33 31,90
4)	69 23,63	33 31,90
5)	69 23,00	33 37,10
6)	69 22,02	33 45,40

Area 2. the White Sea (fig. 4.7.):

1)	66°09,50'N,	40°28,80'E;
2)	66 11,80	40 19,50
3)	66 16,00	40 13,20
4)	66 21,70	40 34,80
5)	69 19,40	40 44,40

As the result of the analysis of the established navigation routes in the selected areas of the Barents and the White Seas including the ice period, the following coordinates were identified as crossings of the main tanker routes:

- Location 1. The Barents Sea: 69°22,00'N 33°37,00'E; (fig. 4.6.)
- Location 2. The White Sea: 66°16,80'N, 40°30,00'E; (fig. 4.7.)

Fig.4.6. Simulation area and point in the Barents Sea

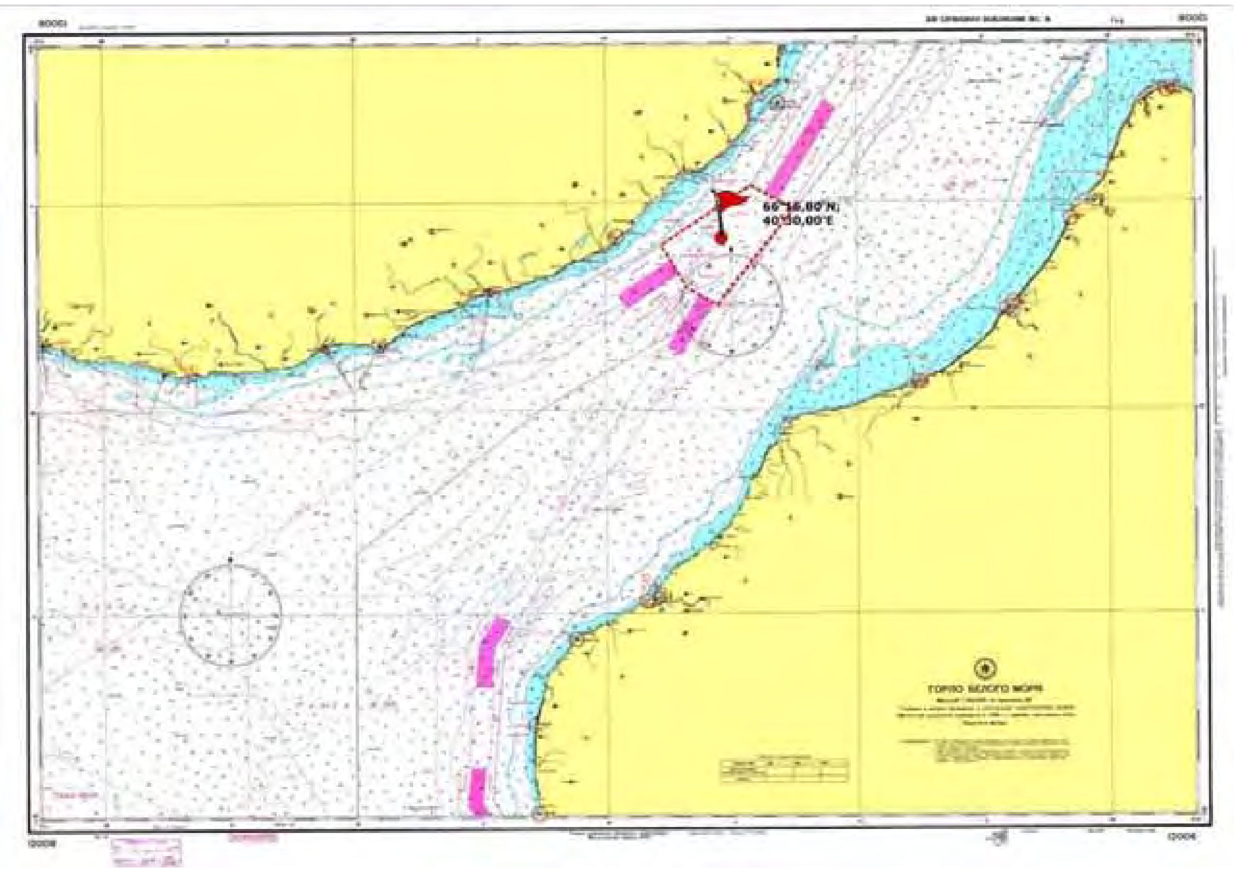


Fig.4.7. Simulation area and point in the White Sea

The selected areas and locations of potential OS were correlated with the mapping of especially sensitive coastal areas presented in Chapter 3 of this Report. The correlation of the selected OS locations with the mapping results showed that Location OS-1 (the Barents Sea) is close to a zone ranked 5 – very high sensitivity; white Location OS-2 (the White Sea) is close to a zone ranked 4 – high sensitivity. Thus, the OS locations selected for simulating are in full accordance with the established criteria.

4.3.3 Hydro-Meteorological and Navigation-Hydrological Conditions in the Simulation Areas

Location OS-1 (69°22,00'N 33°37,00'E) is situated in the Barents Sea near the entrance to the Kola Bay in the area of special attention for navigation. (fig. 4.6). The Kola Bay of the Barents Sea stretches southward inside the mainland. Its mouth is located between the northern point of Toros Island (69°18.00'N;33°27.00'E) and Cape Letinsky. In the mouth of the Bay the shore is high and steep; only in some places the access to water is flat. The West side of the Northern Section of the Bay is formed by smooth slopes of high hills and is more rugged than the East side. The Northern section of the Bay is very deep with the depths reaching 110-319 m. The Northern section never freezes; only in severe winters fast ice forms but breaks all the time due to the water level fluctuation and waves. The hydro-meteorological and navigation-hydrological conditions in location OS-1 are shown in Table 4.3.

Table 4.3. Hydro-meteorological and navigation-hydrological conditions in location OS-1

Season / Conditions	Winter (Jan.-Mar.)	Spring (Apr.-June)	Summer (July-Sept.)	Autumn (Oct.-Dec.)
Average ambient t	-9	-2	+ 12	-3

Conditions \ Season	Winter (Jan.-Mar.)	Spring (Apr.-June)	Summer (July-Sept.)	Autumn (Oct.-Dec.)
Water t	+3	+ 3	+7	+3
Surface water layer density	1,0270	1,0000	1,0000	1,0270
Dominating wind directions	S, SW	N, NE, NW	N, NE, NW	S, SW
Average monthly wind speed	9 m/c	8 m/c	8 m/c	6 m/c
Heaving of the sea	4 m	2 m	2 m	4 m
Permanent current speed	0,5 knot	0,5 knot	0,5 knot	0,5 knot
Tidal currents speed	1 knot	1 knot	1 knot	1 knot
Cloudiness	9	9	9	9
Ice conditions	Not included			

Location OS-2 (66°16,80'N; 40°30,00'E) is situated in the White Sea gullet in the area of higher attention for navigation (fig. 4.7). The White Sea gullet is the strait connecting the northern part of the White Sea and the basin of the White Sea. In the North-West the White Sea is limited by the Tersky Coast, in the South-East – by the the Zimny Coast. The North-East border of the White Sea gullet is considered to be the line connecting the Ponoy River mouth and Cape Voronov (66°31'N, 42°14'E); its South-West border is considered to be the line connecting Tetrino village (66°04'N, 38°14'E) on the Tersky Coast with Cape Zimnegorsky on the Zimny Coast. The gullet's coastline is not very rugged; only Tersky Coast has several small shallow bays. The gullet's shores have shallow banks less than 20m deep and up to 10 miles wide. There are individual hazards on the shallow banks. The seabed terrain in the White Sea gullet includes sudden changes in the depth, numerous banks, seamounts, distinctive depths and individual trenches. The soil in the White Sea gullet is mostly stony; sand is found only in some places near the Zimny Coast. The ice in the White Sea is usually observed from November to May. The ice cover in the White Sea is formed by drifting ice that occupies 90% of the whole Sea area; fast ice is not well-developed and accounts for less than 10%. Earliest of all fast ice is formed at the shallow shore. A specific feature of the White Sea ice is its instability due to the strong tidal currents and winds. Traditionally at high tide ice contraction takes place, while at low tide openings in the ice are observed. The Sea gullet becomes ice-free by the middle of May. Most of the ice is carried out to the Barents Sea. Hydro-meteorological and navigation-hydrological data for OS simulation in the area of OS-2 are given in Table 4.4.

Table 4.4. Hydro-meteorological and navigation-hydrological conditions in location OS-2

Conditions \ Season	Winter	Spring	Summer	Autumn
Ambient air t	- 11	+8	+ 12	+1
Water t	-1,9	+ 2	+7	+2
Surface water layer density	1,0270	1,0230	1,0230	1,0270
Dominating wind directions	S, SW, W	N, NE, E	N, NE, E	S, SW, W
Average monthly wind speed	12 m/c	8 m/c	8 m/c	12 m/c
Wave height	2 m	2 m	2 m	2 m
Current speed	1 km/h	1 km/h	1 km/h	1 km/h
Cloudiness	8	7	8	7
Ice concentration	7/10	---	---	---

4.3.4 Justification of Quantity of Potential Oil Spill

According to the Russian Law the largest possible quantity of oil spilt from oil-carrying vessels is determined as two tanks volume (Resolution of the RF Government No. 613 dd. 21.08.2000). As a rule, the total volume of the two largest adjacent cargo tanks of an oil-carrying vessel is taken for calculations.
To determine the possible quantity of oil spilt in the Barents and the White Seas deadweight groups of tankers transporting oil through the locations selected for OS

simulating were considered. As a result, average volumes of 2 adjacent tanks in line tankers transporting oil along the navigation routes of the Barents and the White Seas were calculated (Table 4.5). For simulating weathering of different oil types on the water surface of the Barents and the White Seas in different hydro-meteorological conditions for each OS location 4 oil types were selected based on the largest estimated volumes of two adjacent tanks. (Table 4.6).

Table 4.5. Volumes of 2 adjacent cargo tanks in the tankers transporting oil on the navigation routes of the Barents and the White Seas

Location	Transportation route	Substance	Tanker deadweight (tons)	Volume of 2 tanks, m^3
Location OS-1 (the Barents Sea)	Vitino – Kola Bay	SGC	70 000	14 000
		Naphtha	50 000	10 000
	Arkhangelsk - Kola Bay	Crude oil	30 000	6 000
	Dudinka - Kola Bay	Crude oil	20 000	6 000
		SGC	50 000	10 000
	Obskaya Bay - Kola Bay	Crude oil	20 000	4 000
	Varandey - Kola Bay	Crude oil	70 000	15 000
	Kolguyev - Kola Bay	Crude oil	20 000	4 000
	Kola Bay - export	Naphtha	50 000	10 000
	Kola Bay - export	Black oil	60 000	12 000
	Kola Bay - export	Crude oil SGC	150 000	20 000
Location OS -2 (the White Sea)	Vitino - Kola Bay	Crude oil SGC	70 000	14 000
	Vitino - export	Naphtha	70 000	10 000
	Vitino - Kola Bay	Black oil	70 000	14 000
	Arkhangelsk - Kola Bay	Crude oil	30 000	6 000

Table 4.6. OS volumes of oil sorts for computer simulation

Location	Substance	Volume, m^3
Location OS-1 (the Barents Sea)	Crude oil (Varandey sort)	20 000
	Black oil	12 000
	Naphtha	10 000
	SGC	20 000
Location OS -2 (the White Sea)	Crude oil (Ukhta sort)	14 000
	Black oil	14 000
	Naphtha	10 000
	SGC	14 000

Thus, for computer simulation of various oil types weathering on the water surface in the Barents and the White Seas in various hydro-meteorological conditions 4 types of oil were selected for each OS location with different physical and chemical parameters; namely, two sorts of crude oil (Varandey and Ukhta), dark oil product (black oil M-100), light oil product (naphtha – stable natural gasoline) and stable gas condensate.

4.4 Results of Simulation of Weathering of Main Oil Types Transported and Transshipped in the Barents and the White Seas

Simulating was carried out for each oil type in 4 seasons with account of all wind directions dominating in each season. Simulating interval for all models is 60 minutes. As a result, there were obtained 88 models of possible OS. 32 models of OS were chosen out of a total number of obtained models (16 models in OS location-1 and 16 models in OS location-2). The scenarios of their development presume oil approaching the coastal line and contamination of sensitive coastal areas, as well as carrying of oil slick into the open sea. Simulating results are presented in Volume II of the present project "Simulation of Weathering of General Oil Types and Petroleum Products on Water Surface of the Barents and the White Seas in Various Hydro-Meteorological Conditions".

Each scenario received a code consisting of the following reference designations (table 4.7.):

Oil type:

- COV – crude oil ["Varandey oil" sort]
- COU – crude oil ["Ukhta oil" sort]
- BO – black oil
- GC –gas condensate
- Na –naphtha

Season:

- Aut – autumn
- Spr – spring
- Win – winter

Wind:

- S – South wind
- SW – South-West wind
- N – North wind
- NW – North-West wind
- W – West wind

OS location:

- 1 – OS location-1 in the Barents Sea
- 2 – OS location -2 in the White Sea

Table 4.7. Codes and brief description of OS scenarios.

№	Scenario code	Brief description of OS scenarios
		Group of scenarios Aut-S-1
1.	COV-Aut-S-1	Leakage from two adjacent tanks of a line tanker of 150,000 tons of deadweight in OS location-1 in autumn period with S wind → discharge of 20,000 m^3 of COV → spread of oil slick on water surface → drift of oil slick towards the shore → approaching the shore and contamination of the coastal line → drift of the slick to the open sea
2.	BO-Aut-S-1	Leakage from two adjacent tanks of a line tanker of 60,000 tons of deadweight in OS location-1 in autumn period with S wind → discharge of 12,000 m^3 of BO → spread of oil slick on water surface → drift of oil slick towards the shore → approaching the shore and contamination of the coastal line → drift of the slick to the open sea
3.	GC-Aut-S-1	Leakage from two adjacent tanks of a line tanker of 150,000 tons of deadweight in OS location-1 in autumn period with S wind → discharge of 20,000 m^3 of GC → spread of oil slick on water surface → drift of oil slick towards the shore accompanied by significant evaporation → approaching the shore and contamination of the coastal line → drift of the slick to the open sea
4.	Na-Aut-S-1	Leakage from two adjacent tanks of a line tanker of 50,000 tons of deadweight in OS location-1 in autumn period with S wind → discharge of 10,000 m^3 of Na → spread of oil slick on water surface → drift of oil slick towards the shore accompanied by significant evaporation → approaching the shore and contamination of the coastal line → drift of the slick to the open sea
		Group of scenarios Aut-SW-1
5.	COV-Aut-SW-1	Leakage from two adjacent tanks of a line tanker of 150,000 tons of

№	Scenario code	Brief description of OS scenarios
		deadweight in OS location-1 in autumn period with SW wind → discharge of 20,000 m^3 of COV → spread of oil slick on water surface → drift of the slick to the open sea
6.	BO-Aut-SW-1	Leakage from two adjacent tanks of a line tanker of 60,000 tons of deadweight in OS location-1 in autumn period with SW wind → discharge of 12,000 m^3 of BO → spread of oil slick on water surface → drift of the slick to the open sea
7.	GC-Aut-SW-1	Leakage from two adjacent tanks of a line tanker of 150,000 tons of deadweight in OS location-1 in autumn period with SW wind → discharge of 20,000 m^3 of GC → spread of oil slick on water surface → drift of the slick to the open sea accompanied by significant evaporation
8.	Na-Aut-SW-1	Leakage from two adjacent tanks of a line tanker of 50,000 tons of deadweight in OS location-1 in autumn period with SW wind → discharge of 10,000 m^3 of Na → spread of oil slick on water surface → drift of the slick to the open sea accompanied by significant evaporation
Group of scenarios Spr-N-1		
9.	COV-Spr-N-1	Leakage from two adjacent tanks of a line tanker of 150,000 tons of deadweight in OS location-1 in spring period with N wind → discharge of 20,000 m^3 of COV → spread of oil slick on water surface → drift of oil slick towards the shore → drift of the slick along the shore→ contamination of the shore
10.	BO-Spr-N-1	Leakage from two adjacent tanks of a line tanker of 60,000 tons of deadweight in OS location-1 in spring period with N wind → discharge of 12,000 m^3 of BO → spread of oil slick on water surface → drift of oil slick towards the shore → drift of the slick along the shore→ contamination of the shore
11.	GC-Spr-N-1	Leakage from two adjacent tanks of a line tanker of 150,000 tons of deadweight in OS location-1 in spring period with N wind → discharge of 20,000 m^3 of GC → spread of oil slick on water surface → drift of oil slick towards the shore accompanied by significant evaporation → drift of the slick along the shore→ contamination of the shore
12.	Na-Spr-N-1	Leakage from two adjacent tanks of a line tanker of 50,000 tons of deadweight in OS location-1 in spring period with N wind → discharge of 10,000 m^3 of Na → spread of oil slick on water surface → drift of oil slick towards the shore accompanied by significant evaporation → drift of the slick along the shore→ contamination of the shore
Group of scenarios Spr-NW-1		
13.	COV-Spr-NW-1	Leakage from two adjacent tanks of a line tanker of 150,000 tons of deadweight in OS location-1 in spring period with NW wind → discharge of 20,000 m^3 of COV → spread of oil slick on water surface → drift of oil slick under the influence of wind and stream → contamination of a large part of water area and the coastal line
14.	BO-Spr-NW-1	Leakage from two adjacent tanks of a line tanker of 60,000 tons of deadweight in OS location-1 in spring period with NW wind → discharge of 12,000 m^3 of BO → spread of oil slick on water surface → drift of oil slick under the influence of wind and stream → contamination of a large part of water area and the coastal line
15.	GC-Spr-NW-1	Leakage from two adjacent tanks of a line tanker of 150,000 tons of deadweight in OS location-1 in spring period with NW wind → discharge of 20,000 m^3 of GC → spread of oil slick on water surface → drift of oil slick under the influence of wind and stream accompanied by significant evaporation → contamination of a large part of water area and the coastal line
16.	Na-Spr-NW-1	Leakage from two adjacent tanks of a line tanker of 50,000 tons of deadweight in OS location-1 in spring period with NW wind → discharge of 10,000 m^3 of Na → spread of oil slick on water surface → drift of oil slick under the influence of wind and stream accompanied by significant evaporation → contamination of a large part of water area and the coastal line

№	Scenario code	Brief description of OS scenarios
		Group of scenarios Aut-S-2
17.	COU-Aut-S-2	Leakage from two adjacent tanks of a line tanker of 70,000 tons of deadweight in OS location-2 in autumn period with S wind → discharge of 14,000 m^3 of COU → spread of oil slick on water surface and drift of oil slick under the influence of wind and stream → contamination of a large part of water area and the coastal line
18.	BO-Aut-S-2	Leakage from two adjacent tanks of a line tanker of 70,000 tons of deadweight in OS location-2 in autumn period with S wind → discharge of 14,000 m^3 of BO → spread of oil slick on water surface → drift of oil slick under the influence of wind and stream → contamination of a large part of water area and the coastal line
19.	GC-Aut-S-2	Leakage from two adjacent tanks of a line tanker of 70,000 tons of deadweight in OS location-2 in autumn period with N wind → discharge of 14,000 m^3 of GC → spread of oil slick on water surface → drift of oil slick under the influence of wind and stream accompanied by significant evaporation → contamination of a large part of water area and the coastal line
20.	Na-Aut-S-2	Leakage from two adjacent tanks of a line tanker of 50,000 tons of deadweight in OS location-2 in autumn period with S wind → discharge of 10,000 m^3 of Na → spread of oil slick on water surface and drift of oil slick under the influence of wind and stream accompanied by significant evaporation → full evaporation of oil products
		Group of scenarios Aut-W-2
21.	COU-Aut-W-2	Leakage from two adjacent tanks of a line tanker of 70,000 tons of deadweight in OS location-2 in autumn period with W wind → discharge of 14,000 m^3 of COU → spread of oil slick on water surface → drift of oil slick under the influence of wind and stream → contamination of a large part of water area and the coastal line
22.	BO-Aut-W-2	Leakage from two adjacent tanks of a line tanker of 70,000 tons of deadweight in OS location-2 in autumn period with W wind → discharge of 14,000 m^3 of BO → spread of oil slick on water surface → drift of oil slick under the influence of wind and stream → contamination of a large part of water area and the coastal line
23.	GC-Aut-W-2	Leakage from two adjacent tanks of a line tanker of 70,000 tons of deadweight in OS location-2 in autumn period with W wind → discharge of 14,000 m^3 of GC → spread of oil slick on water surface and drift of oil slick under the influence of wind and stream accompanied by significant evaporation → contamination of a large part of water area and the coastal line
24.	Na-Aut-W-2	Leakage from two adjacent tanks of a line tanker of 50,000 tons of deadweight in OS location-2 in autumn period with W wind → discharge of 10,000 m^3 of Na → spread of oil slick on water surface and drift of oil slick under the influence of wind and stream accompanied by significant evaporation → full evaporation of oil products
		Group of scenarios Win-S-2
25.	COU-Win-S-2	Leakage from two adjacent tanks of a line tanker of 70,000 tons of deadweight in OS location-2 in winter period with S wind → discharge of 14,000 m^3 of COU → spread of oil slick under conditions of 70% ice consolidation → freeze-in of oil into ice
26.	BO-Win-S-2	Leakage from two adjacent tanks of a line tanker of 70,000 tons of deadweight in OS location-2 in winter period with S wind → discharge of 14,000 m^3 of BO → spread of oil slick under conditions of 70% ice consolidation → freeze-in of oil into ice
27.	GC-Win-S-2	Leakage from two adjacent tanks of a line tanker of 70,000 tons of deadweight in OS location-2 in winter period with S wind → discharge of 14,000 m^3 of GC → spread of oil slick under conditions of 70% ice consolidation → freeze-in of oil into ice
28.	Na-Win-S-2	Leakage from two adjacent tanks of a line tanker of 50,000 tons of deadweight in OS location-2 in winter period with S wind → discharge of

№	Scenario code	Brief description of OS scenarios
		10,000 m^3 of Na → spread of oil slick under conditions of 70% ice consolidation → freeze-in of oil into ice
Group of scenarios Win-W-2		
29.	COU-Win-W-2	Leakage from two adjacent tanks of a line tanker of 70,000 tons of deadweight in OS location-2 in winter period with W wind → discharge of 14,000 m^3 of COU → spread of oil slick under conditions of 70% ice consolidation → freeze-in of oil into ice
30.	BO-Win-W-2	Leakage from two adjacent tanks of a line tanker of 70,000 tons of deadweight in OS location-2 in winter period with W wind → discharge of 14,000 m^3 of BO → spread of oil slick under conditions of 70% ice consolidation → freeze-in of oil into ice
31.	GC-Win-W-2	Leakage from two adjacent tanks of a line tanker of 70,000 tons of deadweight in OS location-2 in winter period with W wind → discharge of 14,000 m^3 of GC → spread of oil slick under conditions of 70% ice consolidation → freeze-in of oil into ice
32.	Na-Win-W-2	Leakage from two adjacent tanks of a line tanker of 50,000 tons of deadweight in OS location-2 in winter period with W wind → discharge of 10,000 m^3 of Na → spread of oil slick under conditions of 70% ice consolidation → freeze-in of oil into ice

With the help of computer simulating there were defined areas of oil pollution resulted from various spills in OS location-1 and OS location-2 (table 4.8., fig. 4.8.-4.9.).

The area of possible oil pollution in case of spills in OS location-1 is the area of the Barents Sea between parallels 69°24'N and 69°10'N, on the West limited by the West side of the Kola Bay from Cape Set-Navolok to the Devkina Pozhnya Bay, on the East – by the East side of the Kola Bay from the Tyuva Bay to Cape Letinskiy and a part of Murmansk coast from Cape Letinskiy to the Kildinskiy Strait (fig. 4.8.; table 4.8.).

The area of possible oil pollution in case of spills in OS location-2 (table 4.8.; fig. 4.9.) is the area of the gullet of the White Sea between the Tersky coast (from Cape Beliy Mokh [66°21' N 40°14' E] to the Kachalovo Stanovicshe Bay) and Zimny coast (from Cape Intsy to Cape Voronov [66°31' N 42°14' E]).

According to simulated results, in case of oil spill in OS location-2 in winter period oil does not approach the shore, as the ice which is formed in the gullet of the White Sea prevents free oil spreading on water surface. Oil sticks to the upper and lower sides of ice and freezes in ice. Average area of polluted ice according to OS scenarios in OS location-2 is about 2,5 km^2. As spring sets in contaminated ice will start melting, and its main part will be carried out by streams from the gullet of the White Sea to the Barents Sea, contamination of coasts resulting from the drift of melting ice with frozen-in oil is also possible.

Table 4.8. Main geographical objects in the oil contaminated areas

№	Group of scenarios	Oil reaching the shore, hours	Main geographical objects in the area of oil contamination
OS location-1. The Barents Sea			
1.	Autumn, South wind (Aut-S-1)	5,5-6,0	West side of the Kola Bay, Cape Set-Navolok
2.	Spring, North wind (Spr-N-1)	9,0-9,5	East side of the Kola Bay from the Bolshaya Volokovaya Bay to Cape Cherniy West side of the Kola Bay, including the Olenya and Pala Bays, Ekaterinskaya Harbor, Cape Glinoetzkiy

№	Group of scenarios	Oil reaching the shore, hours	Main geographical objects in the area of oil contamination
OS location-1. The Barents Sea			
			Islands Toros, Bolshoy Oleniy, Malye and Srednye Olenyi, Shalim, Ekaterinskiy
3.	Spring, North-West wind (Spr-NW-1)	6,8-7,8	East coast of the Kola Bay from Cape Letinskiy to Cape Toporkova Pakhta
OS location-2. The White Sea			
4.	Autumn, South wind (Aut-S-2)	13,0 – 14,3	The Tersky coast of the White Sea from mouth of the Kachalovo Stanovicshe Bay to Cape Beliy Mokh: North coast of the Kachalovo Stanovicshe Bay, the Glubokaya Bay
5.	Autumn, West wind (Aut-W-2)	47,2 – 48,4	The Zimny coast of the White Sea between Cape Voronov and mouth of the Megra River: Cape Tolstiy Nos, mouth of the Mayda River, Cape Oleniy Nos

Fig. 4.8. Zones of possible pollution distribution in case of oil spill in OS location-1. The Barents Sea.

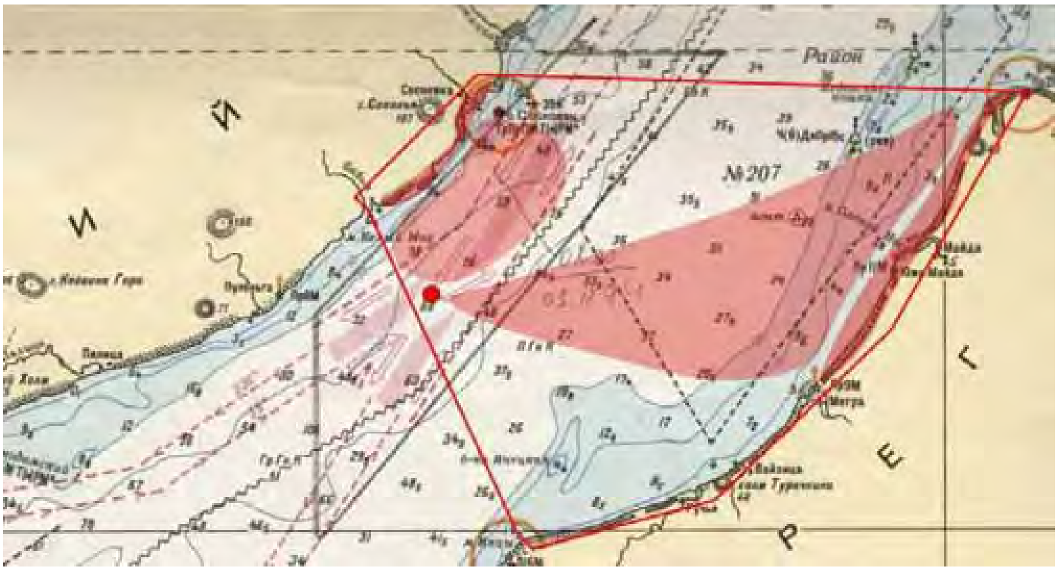


Fig. 4.9. Zones of possible pollution distribution in case of oil spill in OS location-2. The White Sea.

4.5 Description of Possible Consequences of Oil Spills in the White and the Barents Seas

With relation to environmental impact two OS groups can be conditionally distinguished between. If spilt oil is constantly located in the open waters far from the shore, it will in some time disperse in water naturally under the influence of wind and streams and will not constitute a danger for environment. However, if oil reaches the shore, depending on the quality of oil, the effect can be of acute, but short-term character in view of relatively fast oil degradation as, for example, in case of light oils (GC and Na). Contamination of the coast with hard oils (crude oil and BO) can lead to long-terms environmental disturbance which can combine both toxic and mechanical impact (oil wrapping of inhabitants of intertidal zone, pollution of bottom areas and their exclusion out of food reserves of benthophages, etc.).

This fact was confirmed during the analysis of weathering of various oil types on the water surface (Volume II of the present report, for example, for the Barents Sea fig. 73, 146, 221, 304). Simulating showed that, for example, in autumn and spring periods during the first days after Na and GC spill from 40% to 84% of the initial volume of the spill evaporate. Toxic impact would decrease in proportion to weathering of these oils. It is expected that Na and GC spills will have temporary and rapidly recoverable effect – *acute stress*.
It is presumed that under the influence of tidal waves and wind the environment self-purification can take place during one-two seasons.
On the contrary, indexes of BO and crude oil evaporation under similar conditions are significantly lower and fluctuate at the level of 0%-7% within 24 hours. It is assumed that crude oil and BO will reach the shore in practically unchanged condition from the moment of spill, and their expected impact can be characterized as *chronical stress* for coastal ecosystem.

On the shore oil can be accumulated in various cracks, spaces between stones, where it can remain for years. The duration of oil presence on the coast which also means its potential impact on environment depends on the coast structure and tidal regime. This issue will be given more detailed consideration in Chapter 5 of the present report.

In case of oil spill under ice conditions (Volume II, paragraph 2.4-2.5) full freeze-in of oil into ice and its storing until ice melting in May is expected. It is assumed that the biggest part of ice and oil will be carried out to the Barents Sea by the stream.

Oil reaches the shore in 20 cases out of all OS scenarios reviewed in the present work. Below is the characteristic of the shores exposed to simulated pollution taking into account environmental exposure according to calculations of Chapter 3 (initial maps of distribution of general types of hydrobionts in the White and Barents Seas are represented in Appendixes B and C).

Water area of the Barents Sea. OS Area-1:

West side of the Northern section of the Kola Bay of the Barents Sea from Cape Set-Navolok to the Devkina Pozhnya Bay

The shore in the area from Cape Set-Navolok to the Island Toros is high and rocky. A lot of bays, the largest of which falling into OS zone are Olenya and Pala Bays, go into the shore from the Island Toros to the Devkina Pozhnya Bay. The Olenya Bay is narrow and long. Its Northern shore is very high and cliffy; its Southern shore is slightly lower and more sloping. Ice which hinders navigation in the bay is formed only in the Khut Bay in the period from November till April. Shores of the Pala Bay are rocky and almost barren of plant life, edged with narrow shallow water area with low skerries and dry stony seamounts. In the northern part of the Bay the Shalim Island is situated. Ice in the Pala Bay is usually present from December till April covering the Bay from the top to the Shalim Island. During winter ice can repeatedly be broken, carried out of the Bay and formed again. Near the West side of the Northern section of the Kola Bay and in its smaller bays there are islands, islets and many navigational dangers. Islands Olenyi and Ekaterinskiy are mainly composed of granite. The shores of islands are generally steep-to, edged by dry sandy and stony shallow water areas. The shores of Island Ekatirinskiy are very rugged. The soil near the West coast of the North section of the Bay includes stones, sand, shells, silt, and in some places corals. Environmental exposure grade of the coastline is: 3 – in winter, 4 – in autumn, and 5 – in spring and summer.

East side of the Kola Bay from the Tyuva Bay to Cape Letinskiy

East shore of the Kola Bay is hilly, steep and slightly rugged. The shore along the whole length is steep-to and there are no dangers near it. The shores of the Bolshaya Volokovaya Bay are composed of granite, high, steep, in some places abrupt, rugged and edged by stony shallow water areas. Ice in the bays is formed in severe winters, however is frail and easy to break. Environmental exposure grade of the coastline: 3 – in winter, 4 – in autumn, and 5 – in spring, summer.

Murmansk coast of the Barents Sea from Cape Letisnkiy to Kildinskiy Strait

The shore from Cape Letinskiy to Kildinskiy Strait is high, abrupt and steep-to. The coastal line is composed of granite, barren of plant life cliffs. The shore is very rugged with bays, the most significant of which are the Zelenetzkaya-Zapadnaya Bay and Dolgaya-Zapadnaya Bay. Between the shore and isobath 50 there are islets and seamounts. The ground near the shore is stone. In winter drifting ice of local origin is present, in the upper parts of bays continuous ice can be formed. The soil in the bays includes sand, shells and corals. Environmental exposure grade of the coastline is: 3 – in winter, 4 – in autumn, and 5 – in spring and summer.

Water area of the White Sea. OS Area-2:

Tersky coast of the White Sea
The Tersky coast of the gullet of the White Sea extends about 45 miles in WSW general direction. The Tersky coast of the gullet of the White Sea is relatively steep-to. Relief of bottom near the shore is uneven; there is a significant number of hazards near the shore, but the overwhelming majority of them lies within the borders of isobath 10 m. Southward of parallel of the Island Sosnovetz the shore is low and covered by plenty of granite blocks. The shore along the Kachalovo Stanovicshe Bay is high and abrupt. The bay dries and is accessible only for shallow-water vessels at half-tide. During low tide the vessels stay in the bay for draining. Before entering the bay in 6 cable length from the shore there are stony seamounts, behind which it is possible for 1,5 m water draught vessels to be at anchor under the conditions of fresh SW winds. The ground in the bay is silt. The shores of the Glubokaya Bay are not high, but abrupt, stony and covered with reddish moss. There are stones on the tidal flat which edges the shores of the bay. Small vessels can entry the bay at half-tide, keeping away from Capes at its mouth. In bays near the Tersky coast ice is starting to form at the end of September, besides, the bays freeze in winter only for a short period as the ice breaks and ridges. Near-shore fast ice, as a rule, also breaks and ridges under the influence of streams.
Environmental exposure grade of the coastline: 2 and 3 – in summer, 2 and 4 – in autumn, and 4 and 5 – in spring.

Zimny coast of the White Sea

The Zimny coast of the gullet of the White Sea extends 50 miles in SW general direction. In some places the shore is rugged by not wide valleys narrowing into the continent. Almost along the whole length the described shore area is edged by shallow water area not more than 2-2,5 cbl in width; only in the area of Cape Voronov and in the mouths of Maida and Megra Rivers the shallow water area reaches up to 5-10 cbl from the shore. The Zimny coast of the gullet of the White Sea near Cape Voronov is the highest, abrupt, and lowers southward. The North part of the Zimny coast of the gullet of the White Sea is treeless, thin forest covers the area in the mouth of the Megra River. The right shore of the Mayda River is low, the left one is high and abrupt. In the mouth of the Mayda River the shallow water area reaches up to 8 cbl from the shore. The Mayda River freezes in the beginning of November, breaks up in May. Environmental exposure grade of the coastline: 2 – in summer, 2 – in autumn, 1 – in winter, 2 – in spring.

Taking into account the results of seasonal environmental exposure grade, it is important to consider that regardless of the season of OS, oil can continue effecting environment being on the shore for many months (this concerns first of all heavy oils). Therefore, one cannot assert that, for example, “winter spill” in the Barents Sea with environmental exposure grade 3 is less dangerous than “summer spill” with the highest exposure grade 5. Aftereffect can be indeed temporary for such dynamic components as phyto- and zooplankton, whereas spill effect (regardless of the season) can be quite prolonged for birds and near-shore benthos.

4.6 Determination of Optimal Technologies and Equipment for OSR according to Scenarios and Comparative Analysis of Need for OSR Forces and Means as well as Technical Facilities of Specialized Emergency Rescue Forces for OSR in the Barents and the White Seas and Protection of Sensitive Coastal Areas

4.6.1 The Main OSR Strategies and Technologies at Sea

The choice of most optimal offshore oil spill response technologies begins with assigning the objectives of response and development of a strategy for implementation of these objectives which include:

- Ensure maximum possible safety of Special Marine Force personnel and ship crews during OSR operations;
- Provide foremost protection of shores and resources characterized by lowest self-recovery ability;
- Provide reduction of pollution to the level of its minimum environmental effect;
- Minimize environmental damage from spilt oil and response actions;
- Minimize waste resulting from response actions.

Both under ice and ice-free conditions the following general offshore OSR strategies are used, which more or less allow to perform above set objectives of OSR operations; besides, combination of several or all strategies is often used:

- Control over spreading oil;
- Actions near the source of spill;
- Actions aside of the source of spill;
- Protection of the coastal zone.

4.6.1.1 Control of Spreading Oil

Control of spreading oil implies assessment of location and tracking travelling (monitoring) of oil slick. Control is carried out with the help of visual observation from the board of an aircraft both in ice and ice-free period with the following goals:

- Specification of the fact of spill;
- Determination of the extent and configuration of the oil patch;
- Forecasting of spilt oil travelling;
- Transfer of information about current spill condition during OSR operation.

Satellite observation or radio light vessels can be used for monitoring of spilt oil displacement after its detection. Under ice conditions observation of ice situation is very important for decision making in OSR strategy.

4.6.1.2 Actions near and away of the Source of Spill

Actions both near and aside of OS source are generally aimed at containment of oil slick and oil recovery from water surface in order to exclude or minimize oil spread and possible contamination of coastal areas and valuable natural objects.

Today the following main groups of modern response methods (technologies) near and aside of OS source can be distinguished between:

1) Mechanical methods (containment, oil recovery and removal from water surface);
2) Chemical methods (dispersion of oil film for its dissolution and degradation acceleration under the influence of natural factors);
3) Thermal method (oil burning).

In practice combination of different methods is used, moreover, preference is always given to mechanical methods of oil recovery and removal and other methods are used as additional when necessary for effectiveness increase of clean-up activities at sea.

1) Mechanical methods

Mechanical methods of OSR, as a rule, include oil containment with the help of booms and its recovery from water surface with the help of skimmers and oil recovery devices. Mechanical methods of OSR have an advantage over chemical and thermal ones because their use has practically no negative environmental impact. However, mechanical methods of OSR have a number of conditions and restrictions concerning possibility of their application in certain conditions (table 4.9.).

Table 4.9. General restrictions and application conditions of OSR mechanical methods

OSR methods	Heaving of the sea, point	Wave height, m	Stream velocity, knots	Wind speed, knots	Oil viscosity, cSt	Other
Booms						
Catching	3-4	1-1,5	1	14-20	-	- Sufficient number of water craft. – Ice conditions.
Deflecting	3-4	1-1,5	2	14-20	-	
Skimmers						
Threshold	1-3	0,1-1	1	7	<1000	- Availability of temporary storage tanks. – Ice conditions.
Disk	2-3	0,3-1	1	11-16	<1000	
Cable	3-4	1-1,5	1	16-22	>1000	
Vacuum	1	0,1	1	7	-	
Tanks						
Tanks onboard OSR vessels	-	-	-	-	-	- Volume. - Pumping speed.

2) Chemical methods (dispersion)

Chemical methods with the use of dispersants are applied in cases when mechanical oil recovery is impossible, for example, if oil film is not thick enough or if OS is a real threat for shores and environmentally sensitive areas. The use of dispersants has the following conditions and restrictions (Руководство, 2002) [Tove, 2009]:

- Dispersion is used for oil with viscosity less than 2000 sCt;
- Water temperature is higher than oil congelation temperature;
- Oil film thickness is more than 0,1 mm;
- Water depth in coastal areas is not more than 10 m;
- Use of dispersants is possible within 2-5 days from OS moment, i.e. until oil has not undergone atmospheric impact;
- Heaving of the sea is not more than 4 points;
- Wind speed is not more than 22 knots (11m/s);
- Dispersants are not effective in case of GC spills;
- For obtaining a permit for use of dispersants the analysis of ecological situation in OS area is required;
- Only dispersants with MPC for sea fishery areas approved by national authorities of environmental and sanitary control can be used.

Only two types of dispersants are permitted to use on the RF territory: Corexit 9527, OM-6 and OM-84. Permission to use dispersants is issued by state authorities of environemental and sanitary control. The procedure of obtaining the permit for the use of dispersants and other nonmechanical methods of oil film recovery and removal is determined by the“Regulations for Sea Coastal Water Protection from Pollution” and

“Guidelines for Use of Oil Dispersants OM-6, OM-84 and Corexit 9527” RD 31.04.24-86 (ЦНИИМФ, 1986).

3) Thermal methods (burning)

Burning of floating oil can be carried out in free water, in ice and on ice with obligatory use of ignition devices. Burning method also has a number of limitations:

- Wind speed is not less than 20 knots;
- Oil slick thickness is not less than 2-3 mm;
- Oil is unweathered and nonemulsifying, since weathered and emulsified oil requires the use of combustion boosters;
- Outburn oil shall be collected and utilized;
- Oil burning on the spill site should not be carried out in any cases connected with the risk of high gas contamination;
- In order to perform oil burning it is required to have a security plan which foresees consequenses with account of values under threat, possible emission of smoke from outburnt oil, fire-fighting means, etc.

Oil burning in the spill area is the most optimal strategy under the conditions of broken ice. However, oil burning on the spill site is prohibited on the territory of the RF until obtaining a permit of authorized state bodies.

4.6.1.3 Protection of the Shore and Coastal Area

Oil spill response in case of shore contamination is a more time-taking process than OSR on the water surface. Preventing oil from reaching the shore is always more advantageous than carrying out shore clean-up operations. This fact is especially relevant for coastlines of the Barents and the White Seas for the following reasons:

- OSR onshore requires mobilization of a considerable number of human and technical resources, as well as existence of developed onshore infrastructure (access roads to the place of OSR operations, places for encampment, etc.);
- Significant part of the Murmansk Region’s coastline, especially of the Barents Sea, is represented by cliffy and abrupt shores where carrying out any shore clean-up operations is irrational and unsafe;
- Coastal area both in the Barents and in the White Seas is generally represented by tidal flats and barrier islands which trouble shore approach by vessels even ones with shallow draft;
- There is almost no access to the coastline from the continent from the side of the Tersky coast in the Murmansk Region;
- There are no facilities for appropriate handling and treatment of oil-contaminated wastes that is why waste masses which will be recovered during shore clean-up can constitute a serious ecological danger.

Oil spill response in case of shore contamination can take years, demand huge financial expenses and, eventually, is often ineffective, especially under the Arctic conditions, an example of which are the consequences of the incident with the tanker “Exxon Valdez” near the shores of Alaska in 1989.

To protect coastal area and shores the methods which allow either deflection of oil not recovered in the process of OSR at sea, or full protection of the coastal line and sensitive coastal areas from spilt oil are primarily used.

Motion pattern of an oil slick can be changed by affecting its surface with the stream from firefighting equipment from the vessel or with the help of a special unit. However, this method of oil deflection has the following restrictions:

- Is practically not applicable in case of large surface of oil slick;
- Is not recommended in case of significant thickness of spilt oil for reasons of safety;
- Is not applicable for newly-spilt light and volatile oil products (GC, Na);
- Contributes to emulsification if used for spill of fuel oil of type M-100 and crude oil.

In this respect the most efficient method of oil deflection from environmentally sensitive coastal areas is setting protection and deflection booms with the help of fast-speed shallow-draft motorboats in order to isolate coastal zone from oil and prevent its further spread, as well as booms in order to protect narrow bays and small coves.

4.6.2 Influence of Oil Properties on OSR Method Choice

When choosing the strategy and method of OSR it is necessary to take into consideration properties of spilt substance. Thus, crude oil and fuel oil properties allow prompt oil slick containment and OS recovery with the help of mechanical methods (booms and skimmers); it is not recommended to use mechanical methods of containment and recovery for newly-spilt light hydrocarbons because of high risk of fire and explosion. Thus, strategy of containment near spill point for oil and fuel oil is preferable, while for SGC and naphta is unacceptable.

For fire and explosion safety during SGC and naphta spill response it is necessary to observe the following rules:

- Operating of OSR vessels is unacceptable in the area of newly-spilt SGC and naphta where there is a high degree of hydrocarbons evaporation;
- It is not recommended to use mechanical OSR methods for newly-spilt SGC and naphta.

It is not recommended to use skimmers during SGC recovery; however it is possible to use immersed pumping equipment. Volatility of newly-spilt SGC or naphta combined with wind and sea heaving leads to rapid dispersion of its evaporation. Therefore, after the leakage is stopped, a respective danger is of local and temporary character. Thus, after containment and recovery of SGC and naphta spills, it is necessary to take intense measures to provide fire and explosion safety and it is necessary to start oil spill recovery from the water surface only after evaporation of the most dangerous volatile fractions from the spill surface which can cause fire or explosion. In case of SGC and naphta reaching the shore the safest way is not to take any removal actions, especially in the areas of high tidal activity, on cliffy shores where oil will most likely decompose naturally.

Recovery of heavy fuel oil of type M-100 and sulfur-bearing oil (“Varandey oil” sort) also has its difficulties. At low temperatures, in the course of time they solidify and settle on the bottom. In stormy weather sunken oil can be lifted up by tides to the surface and cause secondary pollution. Recolonization of bottom areas covered with oil by marine organisms can start only after some years.

4.6.3 Specific Choice of OSR Technologies under Ice Conditions

Most technologies (methods) of OSR in the Arctic are adapted variants of technologies usually used in the regions of moderate climate in free water. Technical solutions of OSR in free water are technologies which are well-proven and described in detail in special literature, but in typical Arctic conditions, such as ice, extreme low temperatures, limited visibility, strong sea heaving and wind, there emerge serious technical problems.

Effectiveness of accepted OSR technologies in the Arctic decreases because of ice presence on the surface of the seas. Ice conditions in the areas of the Barents and the White Seas considered under the present project are different. The SW part of the Barents Sea and the Kola Bay where the main navigation routes lie does not freeze even in harsh winters and water temperature is above zero all the year round (Barents Sea Pilot Charts, 1995). In this connection, ice conditions were not taken into consideration when choosing OSR technologies in the Barents Sea area of our interest.

In the considered area of the White Sea, namely in the gullet of the White Sea, ice stays from November till May and sometimes even from October till July. Since the state and characteristics of the ice cover are very important when choosing response methods, it is necessary to note that a specific feature of ice cover of the White Sea is its instability caused by strong tidal streams and winds. In the gullet of the sea basin the ice is drifting, during high tide there is ice compacting, during low tide - diverging (Barents Sea Sailing Directions, 1988). Moreover, ice cover of the gullet of the White Sea is broken as a result of regular ice escort of vessels in the ice period. Usually during ice escort icebreaker leaves behind a channel in the middle of which there is broken ice, however if icebreaker passes through the gullet of the White Sea in drifting ice, which is exposed to compacting, the channel can be iced over right after the last vessel of the fleet has passed. Therefore, talking about possible ways of OSR in the White Sea it is necessary to take into consideration presence of drifting and broken ice in the winter period, as well as restrictions for use of standard OSR technologies. Drifting ice in the White Sea generally takes 90% of total sea surface (Barents Sea Sailing Directions, 1988), however, in respect of regular ice escort of vessels in the gullet of the White Sea, ice consolidation index of 70% was accepted for computer simulating.

Presence of unstable ice cover in the White Sea makes additional difficulties for OSR in winter period. Solid ice eases oil recovery, while moveable broken ice vice versa is an obstacle and hinders use of the above mentioned OSR technologies under the ice conditions typical for the gullet of the White Sea in winter period.

4.6.3.1 Restrictions for Application of Mechanical Methods of Oil Spill Response under Ice Conditions

In case of oil spill response under the conditions of broken ice most of challenges connected with the application of the mechanical methods of oil containment and oil skimming are caused by smaller open water area, problems for the vessels involved into operations to move and maneuver and problems to use mechanical skimming. Ice cover hinders the access to oil spill, thus spill in ice holes and under ice can only be eliminated by ice class vessels. Alongside with this, if ice concentration is more than 70 %, one needs to ensure that a specialized vessel can approach oil spill so that natural oil containment is not broken by ice rafts.

Oil and water mass collected under ice conditions contains a lot of sludge and slush, it can cause problems in case there are not enough tanks for its recovery and transportation.

Application of skimmers under ice conditions

Skimmers can be applied if ice concentration is less than 30%, but they can be effective only in combination with booms. If ice concentration is more than 70% large oil skimmers are unable to move. Cable, drum, brush, drum and brush, disc skimmers suit most of all for work under ice conditions, as well as the skimmers specially developed for work under ice conditions, so called “arctic skimmers”. In case of oil skimming in the clusters of small pancake ice (size – less than 2 m) contact with larger ice rafts can lead to the damage of skimmers and other oil recovery equipment. Recommendations for the application of skimmers under ice conditions are given in table 4.10 (Журавель, 2007).

Table 4.10. Recommendations for the application of skimmers under ice conditions

Conditions	Disc skimmer	Threshold skimmer	Arctic skimmer	Cable skimmer
Mixture of oil/sludge/water	NR		NR	R
Ice rafts <2 m in diameter			NR	R
Ice rafts >2 m in diameter	NR	NR	R	R
Oil on floe ice			R	R
Oil under floe ice				R
Oil as thin slicks			R	R

Legend:
NR – nominally recommended. Applied depending on circumstances.
R – recommended / preferable
- not recommended (shaded cells)

Application of booms under ice conditions

The application of booms in sea areas with ice concentration less than 30% does not actually pose a problem. In large drifting fields or if ice concentration is higher than 3/10 (30%) it is almost impossible to apply booms. The installation of booms on anchors for oil spill containment is difficult or useless. It is important to provide day and night control of booms condition to guarantee that booms stay in one place and are not damaged by ice (Guidelines, 2002), but it is almost impossible in drifting ice conditions.

Since ordinary mechanical recovery of oil from water requires separation of oil from ice, the containment of water in ice conditions becomes even more complicated. Special steel pontoons with gaps inside them connected by a carrying rope are applied to hold ice and leak oil. In case of towing through ice oil is washed out of ice and appears on the surface. Usually a second entire boom is required for the containment of oil separated from ice, afterwards skimming can be done in an ordinary way. The existing models of such booms are effective if the current velocity is under 0.8 m/s, wave height is under 2 m and ice concentration is udner 7/10. The installation of steel pontoons is quite labour-intensive and requires exact data on oil sick location and consideration of its drifting under the influence of currents (Журавель, 2007).

4.6.3.2 Restrictions for Application of Chemical Methods for Oil Spill Response under Ice Conditions

The application of dispergation under ice conditions is also substantially limited. For effective dispergation oil should float easily, thus water temperature should be higher than the oi pour point (Руководство, 2002). The average temperature of water in the

White Sea in the winter period is -1.9°C, while the pour point of fuel oil, grade M-100, is, for example, +25°C (GOST 10585–99), thus the application of dispersants for heavy oils is not effective in the White Sea conditions during the winter period. Because of low wave action, i.e. weak mechanical mixing and diffusion difficulties, the application of dispersants in case of the high concentration of broken ice is not effective either.

4.6.3.3 Restrictions for Application of Thermal Methods of Oil Spill Response under Ice Conditions

Oil burning under certain conditions is more effective and least costly in comparison with mechanical skimming and in some situations under ice conditions, especially in broken ice or drifting ice, it is the only applicable method (Руководство, 2002). However, the use of oil burning equipment in Russian seas is not stipulated by the acting laws and the possible application of this equipment requires coordination with the corresponding regulatory authorities (Журавель, 2007). Unfortunately, the conditions of the areas of the Barents and White Seas, covered by this project, make it almost impossible to use an oil burning method for oil spill because shores are located very near and are highly environmentally sensitive. It is also worth mentioning that during the winter period the breeding ground of Greenland seal is located on the White Sea ice, their cubs can suffer if they happen to be in the smoke area because of burning oil.

4.6.3.4 Restrictions for Application of the Shoreline and Coastal Area Protection Method under Ice Conditions

Computer simulation (Vol. II) detected the high probability of oil transfer to the shore in case of possible spills during its transportation through the Barents and White Seas. Thus, the protection of highly sensitive coastal areas, self-recovery of which in the Arctic conditions can take decades, e.g. seal herds areas or seabird colonies, is one of the most important tasks in case of oil spill response in the Barents and White Seas.

The computer model of a spill in the White Sea (Vol. II, art.2.4-2.5) forecasts the full freeze-in of oil into ice quite far from shores, thus oil entrapped by ice will almost represent no hazard to ecologically sensitive areas (Руководство, 2002). However, though all ice in the White Sea rarely melts in the place of its location, in most of cases it is moved to the Barents Sea, during spring melting or ice drift oil frozen-in into ice will be most likely washed off from melting ice and removed by wind and current and can reach the shore.

The computer modeling of oil spill showed that under ice conditions the average area of ice polluted by oil can reach 2.5 km^2, alongside with this, oil freezes in into ice quite quickly (12-13 hours after oil spill). The mechanical recovery of oil, distributed in broken ice on such a large area and under such speed of freeze-in, will be extremely complicated (Руководство, 2002). But if weather conditions allow, one should try to skim some oil from water before its freeze-in into ice. The modeling of oil spill in ice in the White Sea also showed that ice floes polluted by oil may probably concentrate on navigation routes, where icebreaker assistance is performed and ice cover is being regularly broken. Activities and methods that can be applied under solid firm ice conditions can be hardly applied in conditions of drifting ice.

4.6.3.5 Optimal Methods of Oil Spill Response in the Barents and the White Seas in accordance with the Designed Scenarios

To perform OSR operations in accordance with the designed scenarios in the Barents and the White Seas in open water the mechanical methods of oil containment, skimming and recovery from the sea surface as well as mechanical methods of shoreline and outstanding areas protection are most effective and most ecologically secure for the environment.

In case of OSR under typical for the White Sea ice conditions it will be best of all to apply both mechanical oil recovery from water by skimmers appropriate for ice conditions, permanent control of polluted ice till the spring period and activities aimed at the protection of the shoreline from possible oil transfer caused by the melting of ice polluted by oil.

Mechanical oil recovery from water under ice conditions implies the use of large skimming systems including OSR ice-class vessels with a long period of independent voyage, support vessels, high speed boom-laying boats, different types of booms, high capacity skimmers, which types correspond to the types of oil transported, applicable under ice conditions.

OSR techniques based on chemical and thermal methods cannot be recommended today as effective for the chosen scenarios in the Barents and the White Seas because of the following:

- close proximity to navigation routes, where OS is probable, to the shoreline and high ecological sensitivity of shores in OS areas in accordance with the chosen scenarios does not allow to apply the chemical methods of OSR without Net Environmental Benefit Analysis (NEBA); this very reason together with safety reasons make the application of thermal response methods also impossible;
- absence of mechanism of prompt net environmental benefit assessment (NEBA) and obtaining permission for application of chemical methods from the relevant regulatory authorities is a delay factor for OSR;
- absence of wide range of modern dispersants allowed for the application in the conditions of the Russian Arctic;
- scientific and experimental bases for the application of chemical and thermal methods of OSR in the Arctic conditions are not enough developed;
- the effectiveness of existing dispersants and oil burning methods is substantially limited under ice conditions and low temperatures conditions.

Nevertheless, past experience showed that mechanical methods allow to recover not more than 20-30% of spilt oil, under ice conditions this indicator may be even lower. Western countries experience (see Chapter 1) shows that in the Arctic, especially under the ice conditions the application of oil burning methods and especially modern dispersants, successfully tested in cold waters, may be very effective in comparison with mechanical methods. Thus, the further development of modern technologies, study of research results of the neighboring countries and the assessment of applicability of these methods in the Russian Arctic are thought to be very promising, especially for OSR of regional and federal significance, for which the equal application of all OSR resources should be taken into account (dispersants and mechanical means).

4.6.4 Comparative Analysis of Need for OSR Resources and Technical Capacities of Specialized Emergency Forces for OSR in the Barents and the White Seas and Protection of Highly Sensitive Coastal Areas

4.6.4.1 Assessment of Need for OSR Resources in Case of a Large Oil Spill in the Barents and the White Seas

To assess a need for OSR resources in the Barents and the White Seas and resources required for the protection of highly sensitive coastal areas there was applied a standard approach used for OSR plans development (Журавель, 2007), taking into account effective OSR technologies and the properties of oils covered by this project (Par.4.6.3. Appendix D).

Assessment of need for booms for oil containment near the source or aside the source of spill

To estimate the length of booms for oil containment near the source or aside the source of oil spill, the simulation of spills in accordance with the designed scenarios was done, the areas and half-perimeters of spills were estimated taking into account oil properties and probable hydro meteorological conditions (Vol. II). The minimal length of a boom was defined taking into account the maximum half-perimeter of oil slick. The number of orders was defined taking into account that the effective length of the line of booms in the order for joint holdup by OSR vessel and high speed boom-laying boat should not exceed 500 m. It was also taken into account that in case of a large spill, several oil fields or lines appear, it increases the number of orders and respectively the number of water craft.

Assessment of need for booms for the redirection of spilt oil and shoreline protection

The number of booms for the redirection of spilt oil and shoreline protection is defined taking into account the total length of the shoreline that can be polluted because of OS in accordance with the designed scenarios. According to computer simulation (Vol. II) the total length of shoreline areas polluted by oil in the Barents Sea can reach 30 km, in the White Sea – 40 km. The approximate assessment of the number of booms for shoreline protection was performed taking into account the overlapping by booms of passages into bays intrusive into the shore, alongside with this, the length of such a boom should not exceed 1 km.

Assessment of need for oil skimming systems for oil collection and recovery from the water surface

The types of oil skimming systems for application in hydro meteorological conditions of the Barents and the White Seas were selected considering the properties of oils covered (Appendix D) and recommendations for the application of skimmers under ice conditions (table 4.10). Since the application of mechanical methods of oil recovery and removal from the water surface is quite limited for stable gas condensate and naphtha because of their high evaporating capacity and explosion and fire hazards, confirmed by computer simulation (Vol. II), the type of skimmers was defined considering the properties of crude oil and fuel oil M-100 (table 4.11). The number of skimmers was defined so that at least 50% of OS could be skimmed within 12 hours (Семанов, 2005) taking into account the anticipated alterations of OS properties in time (volume, thickness of oil film, formation of oil and water mixture) [Vol.II].

Table 4.11. Choice of a skimmer type

Skimmer	Medium and light oil	Heavy oil	Fuel oil M-100
Oleophilic skimmers			

Skimmer	Medium and light oil	Heavy oil	Fuel oil M-100
Disc, small	+	-	-
Disc, large	+	+	-
Brush	+	+	+
Cylinder, large	+	-	-
Cylinder, small	+	-	-
Cable	+	+	-
Threshold skimmers			
Threshold, small	+	+	-
Threshold, large	+	+	+
Portable	+	+	-

Assessment of need for OSR vessels and auxiliary water craft

The assessment of need for OSR vessels and auxiliary water craft in open water conditions covers recommendations to the functional capabilities of OSR vessels for work in Arctic seas. These vessels are to provide OSR operations both in open water and under ice conditions. It was also taken into account that since transportation routes are far from OSR bases, specialized OSR vessel should be quite autonomous (table 4.12) [Zhuravel, 2007].

The number of water craft required for OSR activities in open water conditions in the Barents and White Seas was defined taking into account the number of the orders of booms and skimmers required, keeping in mind that one OSR vessel, capable to locate a high capacity skimmer on deck, and one high speed boom-laying boat are required for work in the order and recover oil from water.

The number of water craft required for OSR activities during the ice season under drifting and broken ice conditions in the White Sea was defined taking into account restrictions for the application of booms in ice conditions (art. 4.6.3.1) and considering the task to skim 30% of spilt oil during 10 hours, i.e. before oil freezes in into ice (Vol. II). The construction of the orders of booms is not applied in this case and the oil skimming system includes only one OSR vessel and a skimmer suitable for oil skimming in drifting and broken ice conditions.

Table 4.12. Recommended technical requirements for OSR vessels participating in the operations in Arctic seas

No	Properties	Parameters
1.	Vessel quality grading	Not lower LU5 according to the regulations of the Russian Marine Register of Shipping
2.	Deck areas for the placement, maintenance and deployment of equipment	No less than 2 standard 20-feet containers No less than 5 m of space in front of the slipway
3.	Slipways for the launching of oil skimming equipment	Width – no less than 4 m
4.	Propulsion device and maneuvering devices	Maneuvering support at slow speed
5.	Helicopter platform	Helicopter type K-226 (length with running propellers 13,0 m, height 4,15 m, width 3,25 m, maximum takeoff weight 3400 kg, cargo weight 1400 kg, at external load - 1500 kg, operational range - 750 km, capacity 8 ppl)
6.	high speed boom-laying boats	Engines capacity 350-400 h.p.
7.	Special posts and rooms	Posts (bridges) of outboard equipment control, data processing and operations control post, laboratory

No	Properties	Parameters
		room

Assessment of need for tanks for oil and water mixture

Under open water conditions and ice conditions OSR vessel should have tanks dedicated for temporary storage and transportation of skimmed oil and water mixture and possible pumping of oil and water mixture and oil to other vessels included into OSR operations (e.g. a tanker fleet vessel). Since it is almost impossible to skim all slipped oil in case of a large spill, the total accepted volume of tanks and reservoirs for the loading and storage of skimmed oil and water mixture is 2 times smaller than the estimated maximum volume of oil and water mixture (Журавель, 2007).

Assessment of need for OS forces and resources bases

During the assessment of need for OS resources and forces bases the following was taken into account:

– The threat of large oil spills on navigation routes requires establishment of intermediate facilities apart from main OSR stations as well as mobile facilities with equipment for work under open sea conditions (Журавель, 2007);
– Locations OS-1 in the Barents Sea and OS-2 in the White Sea are situated very far from OS resources and forces bases (table 4.14);
– Oil reaches the shore within 5-9 hours from OS in the Barents Sea and within 13-47 hours from OS in the White Sea. Highly environmentally sensitive coastal areas and coasts of the Barents and White Seas, dangerous from the viewpoint of navigation, are among the areas that can be polluted by oil (Vol. II);
– First vessel on stand-by should leave the station within two hours after alarm signal and reach OS within six hours after leaving the station (Семанов, 2005).

Outcome of the assessment of need for OSR resources in case of large oil spill in the Barents and White Seas

On the grounds of the stated above approaches there was done an approximate assessment of minimal need for oil spill and fuel oil spill response resources in accordance with the designed scenarios in the Barents Sea under open sea conditions and in the White Sea under open sea conditions in the ice season under drifting and broken ice conditions.

The assessment of need for OSR resources in case of stable gas condensate and naphtha spill was not done since it is almost impossible to use the mechanical methods of response because of the high speed of hydrocarbon evaporation on a large area. Main response strategy in case of stable gas condensate and naphtha spill is provision of protection at a maximum possible level for the vessels staying in the area of spill and the monitoring of oil slick movement and evaporation.

Need for OSR resources in the Barents Sea under open water conditions

In order to provide effective and timely response to oil spill that can occur as a result of navigation emergencies during oil transportation along the navigation routes of the Barents Sea in accordance with the designed scenarios it is required to have the following minimal set of OSR resources:

1. Ocean type booms for OS containment on the water surface – no less than 4 km;

2. Booms for shoreline protection, including light port type booms and sorbent booms – no less than 5 km;
3. High capacity skimmers:
   - from 100 m^3/h – at least 8 units (total capacity 800 m^3/h);
   - from 250 m^3/h – at least 3 units (total capacity 750 m^3/h);
4. OSR specialized vessels meeting the requirements (table. 4.12), – at least 4 units;
5. Auxiliary lifeboats and boom-laying boats meeting the requirements (table 4.12), – at least 6 units;
6. The nearest OSR resources should be located in such a way that oil containment and oil skimming activities as well as shoreline protection activities could be started no later than 3 hours after OS because oil can reach the shore already after 5 hours after OS.

Need for OSR resources in the White Sea under open water conditions

1. Ocean type booms for OS containment on the water surface – at least 4,5 km;
2. Shoreline protection booms, including light port type booms and sorbent booms - at least 4 km;
3. High capacity skimmers:
   - from 100 m^3/h – at least 5 units (total capacity 500 m^3/h);
   - from 250 m^3/h – at least 2 units (total capacity 500 m^3/h);
4. Specialized OSR vessels meeting the requirements (table 4.12), – at least 7 units
5. Auxiliary lifeboats and boom-laying boats meeting the requirements (table 4.12), - at least 10 units.
6. The nearest OSR resources should be located in such a way that oil containment and oil skimming activities as well as shoreline protection activities could be started no later than 10 hours after OS because oil can reach the shore already after 13 hours after OS.

Need for OSR resources in the White Sea under ice conditions

1. Cable, disc, Arctic skimmers (total capacity at least 400 m^3/h);
2. Specialized OSR vessels of ice class meeting the requirements (table 4.12), – at least 4 units.

4.6.4.2 Comparison of Need for OSR Resources and Technical Capacities of Specialized Emergency Forces for OSR in the Barents and the White Seas and Protection of Especially Sensitive Coastal Areas

Technical capacities and stationing of specialized emergency forces for OSR in the Barents and the White Seas

Emergency preparedness in the Barents and the White Seas is provided by Emergency Forces of FSUE MBASU. The marine professional Emergency Forces of FSUE MBASU is part of the instant readiness forces and resources in the functional OSR sub-system within its area of competence (fig. 4.10). FSUE MBASU is the main enterprise of the Barents and the White Seas basins responsible to the government for emergency preparedness and oil spill response.

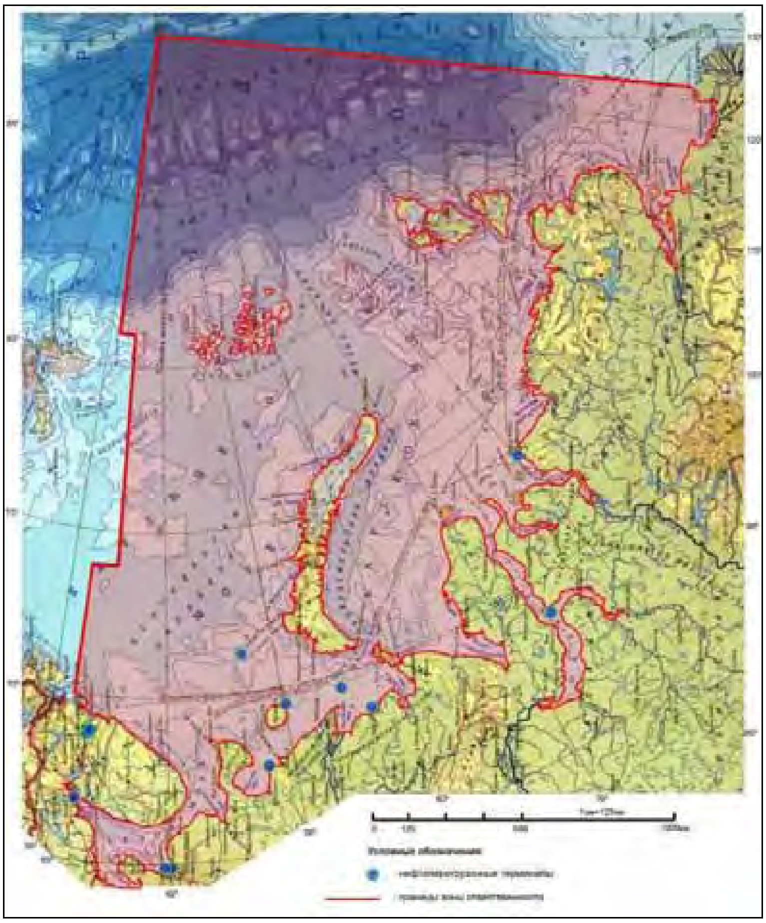


Fig. 4.10. FSUE MBASU responsibility area

Also, resources of the Northern Branch of FSI Gosakvaspas will be involved in OSR operations. The Northern Branch of Gosakvaspas is stationed in Arkhangelsk and is a unit within EMERCOM of Russia (fig. 4.11).
FSI Emergency Department for Special Diving Operations (GOSAKVASPAS) was established in 2001 by EMERCOM of Russia. Participation in OSR operations at sea is one of the activities stipulated by the Charter of FSU Gosakvaspas and its branches. The purpose of the Northern Branch of FSI Gosakvaspas is to protect the population and territories from natural and man-made contingencies in the domestic waters and territorial sea in the White Sea responsibility area.

The base of FSUE MBASU with its equipment and vessels is located in the Southern section of the Kola Bay in the port of Murmansk (fig. 4.11). FSUE MBASU has two branches: the White Sea Branch located in the port of Kandalaksha and the Arkhangelsk Branch EO ASPTR located in the port of Arkhangelsk. The facilities of the Northern Branch of FSI Gosakvaspas with equipment and vessels are located in the port of Arkhangelsk in the mouth of the Northern Dvina River.

To assess the technical capacities of FSUE MBASU and the Northern Branch of GOSAKVASPAS for OSR according to the designed scenarios, the analysis of the inventory of their technical facilities, equipment and vessels that are specially designed or may be used for OSR was made (Table. 4.13); approximate distances from the main stations of FSUE MBASU and Northern Branch of GOSAKVASPAS to Locations OS-1 and OS-2 are taken into consideration (table 4.14); the distribution of OSR equipment and vessels among the stations is taken into consideration.

Table. 4.13. Technical capacities of FSUE MBASU and Northern Branch of GOSAKVASPAS

Facilities and Equipment	Number	Total capacity, m^3/hour	Total length, m	Volume, m^3	Stationing	Equipment owner	Time of arrival at the OS area including readiness time, hours	
							OS-1	OS-2
Skimmers								
Threshold	12 pcs.	1714	---	---	M	MBASU	---	---
	4 pcs.	377	---	---	A	MBASU	---	---
Cable	2 pcs.	39	---	---	M	MBASU	---	---
	1 pcs.	30	---	---	A	MBASU	---	---
Pumping systems /submersible pumps	1 pcs.	2000	---	---	M	MBASU	---	---
	7 pcs.	1440	---	---	A	MBASU	---	---
Booms								
Ocean type	9 sets	---	3000	---	M	MBASU	---	---
Light	5 sets	---	3500	---	M	MBASU	---	---
	2 sets	---	670	---	A	MBASU	---	---
	2 sets	---	500	---	A	Gosakvaspas	---	---
Absorbing	90 sections	---	270	---	M	MBASU	---	---
Fire resistant	7 sections	---	105	---	M	MBASU	---	---
River	1 sets	---	250	---	A	MBASU	---	---
For winter conditions	1 sets	---	50	---	A	MBASU	---	---
Oil trawls	1 pcs.	---	52	---	M	MBASU	---	---
Suspended traps	2 pcs.	---	---	---	M	MBASU	---	---
Tanks and vessels	3	---	---	750	M	MBASU	---	---
	4	---	---	725	A	MBASU	---	---
Vessels								
OSR vessels	3	---	---	---	M	MBASU	4 (2+2)*	26 (24+2)
	2	---	---	---	A	Gosakvaspas	34,5 (32,5+2)	14,5 (12,5+2)
Motor boat	4	---	---	---	M	MBASU	7 (5+2)	---
	2	---	---	---	A	MBASU	---	---
	4	---	---	---	A	Gosakvaspas	---	---
High-speed boats	1	---	---	---	M	MBASU	2 (2+0)	---
	1	---	---	---	A	MBASU	---	---
	6	---	---	---	A	Gosakvaspas	---	---
Aeromobile OSR complexes	1	---	---	---	A	Gosakvaspas	---	

Legend: A – Arkhangelsk, M – Murmansk

**4 (2+2) – Time of arrival at OS area includes the travel time of the vessel from its base to OSR area and the readiness time (0-instant; 0,5 – half-hour; 2 – two-hour)*

Fig. 4.11. Stationing of the basin OSR resources

Table. 4.14. Distances from the OSR resources locations in the Barents and the White Seas to locations OS-1 and OS-2

Route	Distance, miles
FSUE MBASU ➔ Location OS-1	40
FSUE MBASU ➔ Location OS-2	350
Branch Arkhangelsk EO ASPTR ➔ Location OS -2	130
Northern Branch of GOSAKVASPAS ➔ Location OS -2	170
Branch Arkhangelsk EO ASPTR ➔ Location OS -1	420
Northern Branch of GOSAKVASPAS ➔ Location OS -1	440

Assessment of sufficiency of the specialized emergency forces' technical capacities for OSR in the Barents and the White Seas and protection of especially sensitive coastal territories

The comparison of results of the assessment of requirements for OSR resources and the specialized emergency forces' technical capacities for OSR in the Barents and the White Sea shows the following:

The main part of OSR resources and vessels of the specialized emergency forces is concentrated in the port of Murmansk, the Southern Section of the Kola Bay, the Barents Sea, at a considerable distance from the navigation routes of oil transportation. There are no additional en-route bases of OSR resources for the first wave of response in the Barents and the White Seas basins.

In case of oil spill according to the designed scenarios in the Barents Sea under the best favorable conditions the first OSR vessel may reach Location OS-1 at least within 4 hours of receipt of the spill notice, taking into account the readiness time of 2 hours. Consequently, it is practically impossible to ensure timely oil spill response on the navigation routes of the Barents Sea to prevent the shore pollution using mechanical OSR methods.

Specialized OSR vessels including ice-class vessels with unlimited voyage time with significant endurance are, in fact, 2 vessels stationed in the port of Murmansk (FSUE MBASU). In the port of Arkhangelsk there is vessel of the Northern Branch of FSI Gosakvaspas which meets endurance requirements but has no specialized OSR equipment onboard. A specialized OSR vessel from Murmansk will reach OS area in the White sea at least in 24-36 hours. Consequently, mechanical oil recovery of at least some of the oil in case of a spill in the White Sea under ice conditions before the oil freezes into the ice deems impossible.

Arkhangelsk Branch of FSUE MBASU has at its disposal only small vessels which can operate only in the summer navigation period. The White Sea Branch of FSUE MBASU stationed in Kandalaksha has no vessels with OSR equipment onboard.

All the other emergency rescue vessels stationed in Arkhangelsk are mainly designed for coastal operation with a very short endurance period. Even on ice-free water it will be very difficult to use these vessels for OSR in the White Sea gullet, not to mention the Barents Sea.

The total amount of booms at disposal of FSUE MBASU meets the general needs but there is shortage of heavy ocean-class booms. Special booms for ice conditions are only available at Arkhangelsk station, in total length of 50 meters.

FSUE MBASU has a sufficient number of skimmers and oil-recovery devices for ice-free water, including those of high capacity. For ice conditions of the White Sea only three cable skimmers Foxtail type with the total capacity 69 m^3 can be used out of all the FSUE MBASU skimmers; two of them are stationed in Murmansk and one in Arkhangelsk. FSUE MBASU has no Arctic class skimmers.

Specialized OSR equipment of Northern Branch of FSI Gosakvaspas only includes airmobile complex OSR VV-150.

Thus, the technical capacities of the state-managed specialized emergency enterprises for OSR in the Barents and the White Seas today do not meet the requirements of environmental safety of the water and coastal areas of the Barents and the White Seas in the context of oil export development along the Barents Sea Route. The specialized emergency forces need serious replenishment in specialized OSR equipment, establishment of additional support response stations along the coastline of the Barents and the White Seas, increase of the specialized OSR fleet and implementation of new OSR technologies.

4.7 CONCLUSIONS

The research included the qualitative and quantitative analysis of different oil and petroleum products types (further referred to as oil) transported through the Barents and White Seas. Main oil cargos in 2010 are stable gas condensate, naphtha, fuel oil M-100, two types of crude oil ("varandey" and "ukhta"). Regulatory requirements raised to the quality of products and to the data of laboratory analyses included into quality certificates for the lots of commercial products became the basis for the data bank that covered main oil types transported through the Barents and the White Seas as well as for the forecast of oil behavior on the water surface under different hydro meteorological conditions made with the help of computer simulation.

Simulation showed that in many scenarios under different hydro meteorological conditions oil reaches the shore within a short time and poses a threat to environmentally sensitive coastal areas. Oil behavior in case of a spill depends on the properties of oils. There are two conventional types of the forecasting behavior of oil having reached the shore:

a. Oil is very inclined to weathering processes (e.g. evaporation and dispersion) that is why its fast natural destruction is forecasted. In the beginning its toxic impact on the living organisms of coastal areas is forecasted, but it will be decreasing while oil is weathering. Naphta and stable gas condensate refer to this type.
b. Oil is almost not inclined to weathering processes and reaches the coastal area almost in the same condition as it was when it spilt. It is forecasted that there will be a long-term toxic and mechanical impact on living organisms. Crude oil and fuel oil M-100 refer to this group.

OSR strategy and technique should be chosen taking into account oil properties and its forecasted behavior. In case of stable gas condensate and naphtha spill oil slick will quickly spread as a thin film on the water surface. In this case oil containment and recovery on water will be not just ineffective but also very dangerous because of oil high explosion and fire hazard up to the full evaporation of volatile fractions. Thus, the best response strategy is thought to be not to take any measures aimed at OS containment and removal until there is still a danger of explosion or fire. If stable gas condensate or naphtha reaches the shore the safest response strategy will also be taking no measures aimed at its removal especially in the areas with high tidal activity, on cliffed coasts where oil will very probably deteriorate naturally.

In case of fuel oil or crude oil spill the following methods are thought to be most effective and ecologically safest for the environment from the range of possible methods for application in OS conditions according to the designed scenarios in the Barents and White Seas:

- Mechanical methods of containment, collection and recovery of oil from the sea surface with the help of skimming systems which include ice class OSR vessels with a long endurance period, auxiliary vessels, high speed boom-laying boats, different types of booms, high capacity skimmers which types correspond to the types of transported oil and also applicable in ice conditions;
- Mechanical methods of shoreline protection and outstanding areas with the help of high speed boom-laying boats and suitable boom types.

Taking into account natural and logistic limitations that can occur during shoreline treatment operations in the Arctic (by the example of the Murmansk Region) the main task of OSR should be prevention of oil transfer to the coast, especially to the areas of high environmental sensitivity.

The analysis of the resources of state emergency stations, responsible for possible OS locations, showed that the following measures are essential for the improvement of response system and effective coastal protection:

- Establishment of intermediate OSR resources facilities along the vessels navigation routes along the Kola Peninsula;
- Equipping emergency forces with a lacking number of specialized and auxiliary vessels providing OSR operations, including ice class vessels and special equipment appropriate for operations under ice conditions;
- OSR resources should be developed not only for operations at individual facilities with a potential high risk of oil spills (ports, terminals, etc.) but they should be also applicable along the navigation routes of the Barents and White Seas;
- OSR technologies development should concentrate on the prevention of oil transfer to the shore. In this relation the research of modern dispersants application in the Barents and White Seas, also in the coastal areas, is thought to be the most relevant task.

5 NET ENVIRONMENTAL BENEFIT ANALYSIS OF APPLYING VARIOUS EMERGENCY OIL SPILL RESPONSE METHODS TO PROTECT ENVIRONMENTALLY SENSITIVE COASTAL AREAS OF THE BARENTS AND WHITE SEAS

In accordance with the results of oil spills modeling (Volume II), in many of the scenarios, oil reaches the shore in a short period of time and threatens environmentally sensitive areas (Chapter 3). Analysis which was made in Chapter 4 shows that methods of coastline protection such as dispersants or in-situ burning have some limitations, however, at the moment they couldn't be used in the Barents and White seas. The only possible way of protecting the coastline is by boom deployment and mechanical recovery at-sea. However, due to the limited capabilities of emergency services, which are responsible for oil spill response in the impacted areas, predicted pollution of the coastline according to the scenarios is more than likely. Thus, in the coastal and shallow zones the most effective and environmentally friendly response options should be applied to protect sensitive environmental resources from possible adverse effects of oil pollution and further contamination into currently unaffected areas.

5.1 NEBA Concept

When an oil spill occurs, some kind of response is necessary and urgent decisions are often required regarding the different response options available for cleanup. Options for a cleanup response may include containment and recovery, washing/flushing, mechanical/manual removal, in-situ treatments or just leaving the oil to dissipate naturally. However, it is important to remember that there are some instances when a non-active response such as natural recovery may be the most appropriate response. Natural recovery means no attempt is made to remove the stranded oil, to either minimize the possible impact to the environment or because there is no effective method for cleanup. The oil is left in-situ to degrade naturally.

Ecological, recreational and commercial concerns need to be considered, and the consequence of applying or not applying a particular response strategy or cleanup technique needs to be fully understood. However, it is important to acknowledge that some environmental damage is inevitable once spilled oil impacts the shore and that no single response option is likely to be successful in minimizing the impacts. Any action to treat or clean an oiled area results in disturbance, whether by the effects of the response itself or due to the logistics of the operations that may affect an adjacent un-oiled area.

All response options have both limitations and potential benefits, therefore a realistic assessment of the advantages and disadvantages of different responses need to be weighed up and compared both with each other and with natural recovery. This balancing process should aim to achieve the maximum benefit for the environment, taking into consideration the varying priorities and concerns within a given location. This process is sometimes described as Net Environmental Benefit Analysis (NEBA).

Evaluating the conflict between environmental and socioeconomic or aesthetic concerns is extremely important in the spill response decision making process and it should be borne in mind that, not only may there be conflict between ecological resources and socioeconomic interests, but also within each of these categories. For example, a cleanup option may benefit one species while harming another, or may benefit one socioeconomic interest while hurting another.

For most cases of shore oiling, there is little ecological justification for any form of cleanup if only the shore itself is considered, however, moderate cleanup carried out for the sake of interacting systems is acceptable. (Shores consist of the physical features that form the habitat for the organisms as well as the shore organisms themselves i.e. algae, barnacles, mussels etc. Interacting systems impinge on or use or are related to the shore but are not generally regarded as permanent features i.e. birds [nesting, visiting or feeding], marine mammals and socioeconomic considerations such as aquaculture facilities, tourists etc.)

It is important to obtain a consensus on which response options are most likely to minimize environmental and socioeconomic consequences after an oil spill as the impact of a spill and the response will depend on the specific spill conditions, such as the type and amount of oil, weather conditions, habitat where the spill occurred, and effectiveness of the response methods. However, it is essential to take into account not only how desirable, protection of a particular resource is but also to what extent its defence is practicable. Through the adoption of NEBA or net environmental and economic benefit analysis (NEEBA), all stakeholders and interested parties should be able to compare the relative risks of the different spill response options and understand why certain strategies are being proposed during the contingency planning process. The aim, during this process, is to identify response options that either accelerates the time taken for an area to recover naturally or to restore an area, as close as possible, to the pre-spill condition. The use of NEBA allows for discussion and flexibility during the decision process, however, NEBA, although theoretically sound, is a complex process that can be practically difficult and complex to execute. Although often seen as a purely scientific process, in practice it is difficult to develop formulae for a comparative model as it is actually a consensus based process, best conducted during the contingency planning stage. Therefore the process is qualitative rather than quantitative.

The expected frequency and size of spill, and the type of oil likely to be involved along with historical data, local meteorology and environmental sensitivities are all important factors in assessing the risk, behaviour, fate and, potential consequences of spilled oil. It is therefore important to collate as much of this information as possible during plan preparation. If historical data is limited, it may be possible to make comparisons with other areas where the information does exist.

Any NEBA or NEEBA carried out for contingency planning purposes can benefit from a huge amount of published information from case histories, previous spill experience, and field experiments concerning oil on shores as well as the variety of cleanup techniques. The NEBA process has been applied to many past spills worldwide and was prominent in the aftermath of the Exxon Valdez incident whereby Shoreline Cleanup Assessment Teams (SCAT) carried out a greater number of shore assessments than for any other spill. Many organizations such as NOAA, IPIECA and IMO have used this information, available from different environments - the open sea, near shore, and a variety of shorelines - to make general predictions regarding: the ecological and socioeconomic effects of oil; effects and efficiency of different response methods in dealing with oil and; natural cleaning timescales (in the absence of any spill response). However, a note of caution, whilst documentation from previous incidents and studies certainly help with the process, the information is based on factors which are not purely scientific. Therefore this information remains as an assistor rather than dictator.

This information, along with information concerning technical resources, response options, social and economic values will assist in determining what response to recommend or take in the event of an incident. It should also be borne in mind that common sense and consensus-forming are just as important in the decision making process as quantifiable scientific information.

When conducting NEBA evaluation process the following steps are required:

- Collect information on physical characteristics and environmental resources of the area;
- Review previous spill case histories and experimental results which are relevant to the area and to response methods which could possibly be used;
- On the basis of previous experience, predict the likely environmental outcomes if the proposed response is used, and if the area is left for natural clean-up;
- Compare and weigh the advantages and disadvantages of possible responses with those of natural clean-up (weigh the advantages and disadvantages to use a particular response strategy with case histories examples).

5.2 Assessment of Different Oil Spill Response Technologies Considered to be Used in the Barents and White seas

The initial activities undertaken during the early stages of a spill response may have a lasting impact on the long-term site clean-up requirements as well as the environment. Therefore, once the type of oil spilled and its risks are understood, different response strategies need to be considered to minimize environmental damage.

The focus of a spill response on the open water within the Barents and White seas is on mechanical recovery. In an effort to prevent oil coming ashore, the physical containment of floating oil at sea is undertaken by the use of natural or man-made booms and, recovery by the use of skimmers. Containment and recovery at sea by booms and skimmers will, in most cases, be only partially successful due to the limitations of the boom performance and the rapid spread of the oil over the open sea. To maximise collection and recovery, thorough training and a high level of seamanship is required in manoeuvring multiple vessels and booms at low speeds. The wave height, wind direction and current speed will all affect the performance of the system. Therefore, a full understanding of the affect of these on the boom is required to ensure successful recovery of the oil.

Field studies have shown that conventional at-sea mechanical recovery technologies operate at significantly lowered efficiencies when sea ice is present. Sea ice, particularly dynamic drift ice, affects the functionality of both boom and skimmers and also impacts vessel operations, which may limit or preclude the ability to operate certain classes of vessels. Cold weather conditions can further complicate mechanical recovery as machinery is vulnerable to extreme cold whilst vessel-based equipment is vulnerable to icing as sea spray freezes on exposed surfaces.

The focus of shoreline protection and clean-up is usually more straight forward and does not normally require specialist equipment. However, the inappropriate use of equipment and techniques can aggravate the damage to the environment already caused by the stranded oil. The cleanup can be further hampered during winter conditions due to extreme cold which makes it difficult to work in, reduced daylight hours and the changes in the oil itself in response to cold temperatures.

Response strategies involve different potential technologies and the benefits, drawbacks, and limitations of each different response option needs to be analysed in terms of resources and climatic conditions. It is important that consideration is given to the different types of shorelines and their protection measures as well as the most appropriate clean-up methods to adopt. However, it needs to be borne in mind that the socio-economic and aesthetic factors as well as the ecological factors also have a bearing on the method and degree of clean-up required. This type of evaluation helps identify the different scenarios in which a response option such as low pressure flushing may be of a net environmental benefit compared to say, monitoring or mechanical response options.

Taking the aforementioned issues into consideration, the different response options to be considered in the Barents and White seas are as listed below:

At-sea:
- Monitor and Evaluate;
- On-water containment and recovery;
- Dispersant spraying;
- In-Situ Burning.

Onshore:
- Natural recover (monitoring / do nothing);
- Manual removal / cleaning;
- Mechanical removal;
- Berm replacement;
- Vacuum tanks /trucks;
- Vegetation cutting / removal;
- Flooding / warm water washing;
- Low pressure ambient flushing;
- High pressure ambient flushing;
- High pressure hot water flushing;
- Steam cleaning;
- Sand blasting;
- Sediment tilling and acceleration;
- Bio-remediation.

On the basis of previous experience a description of the primary use of the cleanup response and its biological and physical affects was prepared (Table 5.1).

Table 5.1 Description of the primary use of the cleanup response and its biological and physical affects

1.	Monitor and evaluate (Offshore)
Description	Allowing the oil to weather naturally. Constantly monitoring the situation to ensure that oil is dissipating and is not posing a threat to sensitive resources. Aerial surveillance will be required to effectively monitor the situation. Requires an understanding or the characteristics of the oil and how the oil may weather. An analysis of the oils trajectory will also need to ensure that is not going to impact a sensitive area
Primary use of clean-up technique	Offshore incidents where the oil is likely to dissipate naturally. When containment and recovery is not feasible due to weather conditions.
Physical effects	Oil remaining on the surface may drift towards the shoreline
Biological effects	Minimal, although in shallow waters with low flushing
Limits in Ice Conditions	The presence of ice can impact oil behaviour by trapping the oil, controlling the rate of spread, and making it difficult to track. Oil trapped under ice may freeze and remain there as it practically cannot evaporate. The oil will move with the ice until the spring melt and may ultimately be released some distance from the spill site. An autumn or winter spill can transfer wildlife impacts to the spring or summer. Thus arctic oil spills not only affect resident populations present at the time of the spill, they also affect migratory species seasons later. Oil spilled on the surface of an ice sheet tends to pool in ice depressions, and

	may be trapped under snow cover.
2.	**On-water containment and recovery**
Description	Mechanical recovery of oil spills in open water or near-shore environments involves the physical containment of the oil within natural or man-made barriers and the subsequent removal of the oil from the water surface.
Primary use of clean-up technique	Used on at-sea oil spills to concentrate oil to a thickness that will permit recovery and, to limit the amount of oil that may ultimately contaminate the shoreline.
Physical effects	– On-water recovery requires trained operators and specialist equipment and has at best a 20% recovery rate; – Recovery during winter conditions will be less effective as mechanical recovery equipment fails at relatively low ice concentrations. May be used in broken ice conditions of up to a maximum of 30%.
Biological effects	Minimal, although in shallow waters, vessel or boom anchors can disturb benthic communities.
Limits in Ice Conditions	Mechanical recovery technologies operate at significantly lowered efficiencies when sea ice is present. The presence of dynamic drift ice interferes with the ability to contain oil with sufficient thickness to recover it. Sea ice may reduce the effectiveness of containment booms by interfering with the boom position, allowing oil to entrain or travel under the boom, or causing the boom to tear or separate. Ice conditions ranging from 30% to 60% coverage may present the biggest challenge to mechanical response, as conventional booms are likely to be ineffective, but ice conditions are not sufficient to afford natural containment of spills. In areas of 70% ice coverage, attempting a containment and recovery response would be almost pointless. Most technologies used in responding to oil spills in sea ice have been adapted from those typically used on open water and land. While some on-water response technologies may be transferable to open water arctic conditions, sea ice has been demonstrated to reduce the efficiency of many response methods.
3.	**Dispersant**
Description	The application of a group of chemicals applied to a slick to enhance the rate of natural dispersion and accelerates the bio-degradation process
Primary use of clean-up technique	Increases the rate of natural dispersion by reducing the surface tension between the oil and water, which promotes the formation of a greater number of smaller droplets than would otherwise be produced by wave action alone. Dispersion of the oil into the water prevents the formation of persistent water-in-oil emulsions and residues that are difficult to clean up. Usually used when it is desirable to reduce the amount of floating oil to minimize damage to shorelines, wildlife and other sensitive resources.
Physical effects	– Do not physically remove oil for the sea, they simply enhance the rate of natural dispersion; – May substantially reduce the potential environmental damage by treating the spill at an early stage before it reaches the shoreline; – Most crude oils can be dispersed provided they are treated fairly soon after they have been spilt; – Heavy fuel oils are more difficult to disperse and may be impossible to disperse in calm seas and at low temperatures.
Biological effects	– Dispersing oil into the sea will expose some marine life to dispersed

	oil; – The dispersed oil may be toxic to aquatic life particularly shellfish which are sensitive to dispersed oil; – Require to pass ecotoxicology tests relevant to the area in which they are to be used; – In shallow water or in areas with low water exchange, dispersed oil concentrates will persist
Limits in Ice Conditions	Dispersant use in high concentrations of broken ice is usually not practical due to a lack of wave energy i.e. little mechanical mixing, this may be overcome to a certain extent by the use of ice-breaker vessels. Aerial application is likely to be impractical due to the difficulty of applying dispersants between floes.
4.	**In-Situ Burning**
Description	In-situ burning is a response technique that involves the controlled burning of oil at or near the spill site.
Primary use of clean-up technique	Has the potential to rapidly remove large amounts of oil from the seas surface in a relatively short period of time. This can prevent the oil from spreading to other areas and contaminating the shoreline. Burning is a final one-step solution and there is no need for storage, transport or disposal.
Physical effects	– In-situ burning offshore requires trained operators and specialist equipment but has a potential recovery rate of 98%; – Fire booms are expensive, not widely available, heavy and difficult to deploy; – Requires at least 2-3mm oil thickness.
Biological effects	– Toxic emissions from the black smoke plumes; – Burn residue needs to be recovered or it will sink; – Up to 10 km downwind exclusion zone is required to protect response workers, public and wildlife; – Crude oils high in sulphar would likely present health and safety concerns upon ignition; – Creates heat at the air-water interface with potential environmental and ecological consequences.
Limits in Ice Conditions	Fire booms are difficult to deploy in ice and can be damaged. Oil concentrates at ice edges or trapped in ice leads can only be burned when the oil thickness is at least 2-3 mm. Small-scale studies indicate in-situ burning of some crudes in sea ice to have efficiency rates of between 35-50%. With ice coverage of 30-60% in-situ burning operations face many of the same constraints as mechanical recovery because of the challenges deploying containment boom.
5.	**Natural recovery (monitoring/do Nothing)**
Description	No attempt is made to remove any stranded oil and the oil is left to degrade naturally.
Primary use of clean-up technique	Used for oil on high energy beaches where natural removal rates are fast; where the degree of oiling is light or by a non-persistent oil (e.g. diesel) that will evaporate; where access is dangerous or severely restricted or; where clean-up would cause more damage.
Physical effects	– Some oil may remain and could cause contamination of previously cleaned areas; – Environmentally sensitive areas may take an extended period to recover.
Biological effects	– This method may be inappropriate for areas used by high numbers of animals or endangered species due to the smothering effects of the oil and its toxicity; – There is the potential for the oil to be incorporated into the food

	chain; – There is a potential delay in an area's recovery, if organisms will not settle on residual oil.
Limits in Ice Conditions	Natural recovery may not be appropriate immediately prior to freeze-up, as the oil would be covered and incorporated into the ice, and potentially be remobilized during the next thaw. However, natural recovery would be preferred for light oils that would evaporate during thaw periods.
6.	**Manual removal/cleaning**
Description	This is the most common method of shoreline clean-up, where removal of surface oil, oiled sediment and debris is by gloved hand, rakes, shovels, trowels, scrappers, pitchforks, sorbents, etc. and placed in containers i.e. drums, buckets, bags, etc; may also include sifting of sand for removal of tar balls.
Primary use of clean-up technique	Used for light to moderate oiling conditions on mud, sand, gravel and cobble beaches; for shorelines where vehicular access is restricted or; where the substrate is unable to support heavy equipment.
Physical effects	– Can require a large number of manual labourers and is a slow process, particularly during winter conditions; – Selective removal of oiled material which may cause some disturbance of the sediment; – A disadvantage is the risk of injury to personnel from slips, trips and falls.
Biological effects	– Foot traffic may cause disturbance to organisms but this can be minimalised by proper control of crews; – Disturbs, and can remove, shallow burrowing organisms; – Allows for rapid recovery of an area.
Limits in Ice Conditions	Worker safety is an important concern as extreme cold temperatures impact personnel and have the potential to significantly slow or even halt oil spill response operations. Wet ice is very slippery and caution must be exercised if personnel are working where there are leads, thin ice or mobile ice. Manual removal is appropriate for small amounts of surface or sub-surface oil but practicality decreases as the amount of oiled areas and the volume of oiled snow increases.
7.	**Mechanical removal**
Description	Involves removing the oil and oiled sediment by tractors, front-end loaders, backhoes, graders, bulldozers, draglines, etc.
Primary use of clean-up technique	For removal of large quantities of oil on mud, sand, gravel or cobble beaches wherever the surface sediment or substrate is amenable to and accessible to heavy equipment; can also be used to remove heavily oiled vegetation; to expose buried oil.
Physical effects	– Requires vehicular access to the shoreline which can be limited in remote areas; – Disruption of sediment, reduction of beach stability which may lead to erosion and beach retreat – Leaves oil on beach.
Biological effects	– Disturbs and removes both shallow and deep burrowing organisms – Re-stabilization of substrate and repopulation of indigenous species is extremely slow, new communities could develop in the interim.
Limits in Ice Conditions	Machinery is vulnerable to extreme cold. Pumps and hoses are an integral part of most oil spill response systems, and without warming systems they are vulnerable to freeze-up. Metal is also subject to brittle failure at subzero temperatures, therefore, mechanical response devices designed for temperate oil spills must be redesigned with

	arctic-grade metals, fittings, and seals reliable in extreme cold conditions.
8.	**Berm replacement**
Description	Mechanical equipment pushes oiled material from the upper tidal zone down to the intertidal (surf) zone to accelerate natural cleaning by washing out the oil.
Primary use of clean-up technique	Used on sand or sand-gravel beaches where the oil has been left stranded by storms or very high tides; used on cobble and gravel beaches where removal of the contaminated sediment may cause erosion of the beach or backshore area; used on recreational beaches that require to be cleaned quickly.
Physical effects	– Requires vehicular access to the shoreline which can be limited in remote areas; – Disruption of the top layer of substrate; – Leaves some oil in the intertidal area; – Oil released from the sediment could contaminate other areas.
Biological effects	– Recovery of organisms is usually more rapid than with removal of the substrate; – Oil released from the oiled sediment could endanger other animal and plants if close to sensitive areas.
Limits in Ice Conditions	Care must be exercised when using machinery on ice packed shorelines as it is more difficult to manoeuvre in slippery conditions. Tracked vehicles or machinery with tyre chains are not suitable as the oiled snow/ice will adhere to the tyres and could potentially contaminate other 'clean' areas.
9.	**Vacuum tanks/trucks**
Description	A vacuum unit is connected to a flexible hose with a suction head that recovers floating or pooled oil.
Primary use of clean-up technique	Equipment can range from small portable units to large super-suckers that are used to vacuum up oil that has pooled in natural depressions; vacuum floating oil in the absence of skimmers or; vacuum oil collected in man-made trenches on firm sand/mud beaches.
Physical effects	– Requires vehicular access to the shoreline which can be limited in remote areas; – Equipment may not perform well in winter conditions; – Some oil may be left behind; – Requires excavation of trenches 0.5 to 1.0 m in depth.
Biological effects	– Removes organisms at trench locations; – Potential effect from oil left on the shoreline; – Recovery depends on persistence of remaining oil at the trenches.
Limits in Ice Conditions	Machinery is vulnerable to extreme cold. Pumps and hoses are an integral part of most oil spill response systems, and without warming systems they are vulnerable to freeze-up. Metal is also subject to brittle failure at subzero temperatures, therefore, mechanical response devices designed for temperate oil spills must be redesigned with arctic-grade metals, fittings, and seals reliable in extreme cold conditions.
10.	**Vegetation cutting/removal**
Description	Oiled vegetation is cut by hand using weed whackers, blades etc. collected by hand or raked and then bagged for disposal.
Primary use of clean-up technique	Used on oiled vegetation such as wetlands, seagrass beds or kelp beds.
Physical effects	– Due to extensive labour, it can cause disturbance of both roots and

	sediment; – May cause beach erosion due to vegetation loss.
Biological effects	– Trampled areas will recover slowly; – Removes and crushes some organisms as well as destroying habitat; – Cutting at the base of the plant may allow oil to penetrate the substrate.
Limits in Ice Conditions	Worker safety is an important concern as extreme cold temperatures impact personnel and have the potential to significantly slow or even halt oil spill response operations.
11.	**Flooding / warm water washing**
Description	Large volumes of ambient or warm seawater is placed above the oiled shore and then pumped at low pressure (below 100 psi) through a header pipe. On porous sediment, the water flows through the substrate pushing the oil to the surface and then down the shore for collection. On saturated, fine-grained sediment, the water flushes the oil on the surface.
Primary use of clean-up technique	In heavily oiled areas with little to moderate energy shorelines, where the oil is still fluid and adheres loosely to the substrate. For sticky or weathered oil, the water will require heating to soften the oil while a cold flush moves the loosened oil to the shoreline for collection.
Physical effects	Does not disturb the surface to any great extent; potential for re-oiling if not properly contained and collected at the shoreline
Biological effects	- When used with ambient seawater, most organisms are left in place and alive; - The hotter the temperature, the more lethal the effect on organisms.
Limits in Ice Conditions	Not appropriate if the shoreline is iced as access will be restricted and collection of the oily water will not be possible. Washing (flushing and collection) is only appropriate if water does not freeze and encapsulate the oil. Transferring the collected oily waste that contains a mixture of small ice chunks or slush under freezing temperatures presents a major challenge. Machinery is vulnerable to extreme cold. Pumps and hoses are an integral part of most oil spill response systems, and without warming systems they are vulnerable to freeze-up.
12.	**Low pressure (ambient) flushing**
Description	Ambient temperature water is sprayed at low pressure (< 10 psi) from hand-held hoses to lift oil from the substrate for collection at the shoreline. Can be used in conjunction with flooding to prevent released oil from re-adhering to the substrate downstream of the treatment area.
Primary use of clean-up technique	Used to flush fluid oil from cobbles, boulders, rocks, man-made structures and along vegetated banks where oil is trapped in the vegetation.
Physical effects	– Does not disturb the surface to any great extent; – Potential for re-oiling if not properly contained and collected at the shoreline.
Biological effects	– If containment methods are not satisfactory then oil and oiled sediment may be flushed into offshore areas; – Oil not recovered can affect organisms down-shore of the treatment area.
Limits in Ice Conditions	Not appropriate if the shoreline is iced as access will be restricted and collection of the oily water will not be possible. Washing (flushing and collection) is only appropriate if water does not freeze and encapsulate the oil. Transferring the collected oily waste that contains a mixture of small ice chunks or slush under freezing temperatures presents a

	major challenge. Machinery is vulnerable to extreme cold. Pumps and hoses are an integral part of most oil spill response systems, and without warming systems they are vulnerable to freeze-up. Worker safety is an important concern as they need appropriate PPE to protect them from the freezing spray.
13.	**High pressure (ambient) flushing**
Description	To remove oil that has adhered to hard substrates or man-made structures by spraying at a pressure of 100 – 1000 psi for collection at the shoreline. If low water volumes are used then collection of the oil may be by sorbents placed directly below the treatment area.
Primary use of clean-up technique	Preferred method to remove oil adhering to man-made structures, boulders and rocks; when a directed water jet can remove oil from hard-to-reach areas.
Physical effects	– Can disturb the surface of the substrate and wash oil into subsurface sediment; – May erode shorelines of fine sediment if inappropriately applied.
Biological effects	– Removes most of the animal and plant life along with the oil, – if containment methods are not satisfactory then oil and oiled sediment may be flushed into offshore areas; – Oil not recovered can affect organisms down-shore of the treatment area.
Limits in Ice Conditions	Not appropriate if the shoreline is iced as access will be restricted and collection of the oily water will not be possible. Washing (flushing and collection) is only appropriate if water does not freeze and encapsulate the oil. Transferring the collected oily waste that contains a mixture of small ice chunks or slush under freezing temperatures presents a major challenge. Machinery is vulnerable to extreme cold. Pumps and hoses are an integral part of most oil spill response systems, and without warming systems they are vulnerable to freeze-up. Worker safety is an important concern as they need appropriate PPE to protect them from the freezing spray.
14.	**High pressure hot-water flushing**
Description	To mobilize weathered and viscous oils from surfaces by the use of hand-held spray wands at a temperature of 90°F (32°C) - 171°F (77°C) at a pressure of 100 – 1000 psi, to remove oil from the substrate for collection at the shoreline.
Primary use of clean-up technique	Preferred method to remove oil strongly adhering to man-made structures, boulders and rocks
Physical effects	– Can disturb the surface of the substrate and wash oil into subsurface sediment; – May cause some damage to the surface of the rock or man-made structure.
Biological effects	– Removes all of the animal and plant life along with the oil; – May also affect sensitive habitats, if the hot water is allowed to drain across; – Oil not recovered can affect organisms down-shore of the treatment area; – If containment methods are not satisfactory then oil and oiled sediment may be flushed into offshore areas.
Limits in Ice Conditions	Not appropriate if the shoreline is iced as access will be restricted and collection of the oily water will not be possible. Transferring the collected oily waste that contains a mixture of small ice chunks or slush under freezing temperatures presents a major challenge. Machinery is vulnerable to extreme cold. Pumps and hoses are an

	integral part of most oil spill response systems, and without warming systems they are vulnerable to freeze-up. Worker safety is an important concern as they need appropriate PPE to protect them from the freezing spray.
15.	**Steam cleaning**
Description	Steam or hot water is sprayed at a temperature of 171°F (77°C) - 212 °F (100°C) at a pressure of 2000 psi, to remove oil from the substrate for collection at the shoreline.
Primary use of clean-up technique	To remove heavy residual oil from boulders, rocks or man-made structures
Physical effects	Adds temperature of less than 212°F to the surface.
Biological effects	– Complete destruction of all plant and marine life within the spray zone; – May also affect sensitive habitats, if the hot water is allowed to drain across.
Limits in Ice Conditions	Not appropriate if the shoreline is iced as access will be restricted and collection of the oily water will not be possible. Transferring the collected oily waste that contains a mixture of small ice chunks or slush under freezing temperatures presents a major challenge. Machinery is vulnerable to extreme cold. Pumps and hoses are an integral part of most oil spill response systems, and without warming systems they are vulnerable to freeze-up. Worker safety is an important concern as they need appropriate PPE to protect them from the freezing spray.
16.	**Sand blasting**
Description	The use of sand at a velocity of 70 - 80 psi to remove oil from substrates.
Primary use of clean-up technique	Used for aesthetic purposes to remove thin residues of oil from man-made structures and solid/hard substrates that may have been subject to heavy oiling.
Physical effects	Can cause surface damage.
Biological effects	– Complete destruction of all organisms within the blast zone; – Can cause destruction of organisms directly below or adjacent to the structure; – Possible smothering of down-shore organism; – Unrecovered used sand will introduce oil sediment into the adjacent habitat.
Limits in Ice Conditions	Not practical in ice and snow conditions.
17.	**Tilling and aeration**
Description	To enhance the rate of degradation by breaking up the surface layers or to expose subsurface oil by the use of manual methods or mechanical equipment such as tractors pulling discing equipment, ploughs and cultivators.
Primary use of clean-up technique	Used on non-recreational sand, sand-gravel or pebble beaches that can support mechanical equipment or foot traffic or on areas where the oil is stranded above normal high waterline.
Physical effects	– Disrupts surface layer of substrate; – Leaves oil on the shoreline; – Potential for release of oil and oiled sediment into adjacent bodies of water.
Biological effects	– Disturbs shallow burrowing organisms by exposing them to the oil

	by mixing it into the sediment; – Repeated mixing could delay re-establishing organisms; – Possible effects from persistent oil.
Limits in Ice Conditions	Inappropriate if snow is present as the snow acts as a natural oil sorbent and therefore, would be more appropriate to use manual recovery. Try to avoid collecting large volumes of oiled snow.
18.	**Bio-remediation**
Description	Accelerated biodegradation of the oil by the addition of nutrients (bio-enhancement) and micro-organisms (bio-augmentation).
Primary use of clean-up technique	Bio-degradation can be enhanced by applying nutrients or micro-organisms. The amount of degradation will vary with the oil type and environmental conditions.
Physical effects	– Effects are not noticeable for a long tome, usually at least one season after fertilizers have been applied, therefore this technique might not be appropriate in highly visible areas; – High success rates in controlled areas, however high tide can remove it all from the shoreline in one cycle; – Not a quick fix – takes time and natural bio-degradation rates are dependent on the environment.
Biological effects	– Nutrients are soluble in water and can cause accelerated growth in algae in near shore waters; – The addition of micro-organisms may affect the existing ecosystem
Limits in Ice Conditions	Not suitable if snow or ice is present on the shoreline.

Onshore response methods can be classified into non-aggressive and aggressive but whichever method is chosen, the response will have an impact on the environment; some types of stressors that a response generates, and therefore must be considered when deciding different response strategies, include:

- Air pollution (in-situ burning)
- Trauma
- Exposure to the oil
- Heat
- Waste generation

Nonaggressive shore cleaning (methods which have been shown to have minimal impact on shore structure and shore organisms) include:

- Vacuum removal of pooled oil;
- Physical removal of surface oil from firm sandy beaches using machinery such as front-end loaders (avoiding the vehicles mixing the oil into the sand, and the removal of underlying sediment);
- Manual removal of oil, asphalt patches, tar balls etc., by small, trained crews;
- Collection of oil using sorbent materials (followed by safe disposal);
- Low-pressure flushing with ambient temperature seawater;

In appropriate circumstances these methods can be effective, but they also may be labour-intensive and clean-up crews must be careful to minimize damage by the wheels of heavy vehicles, trampling by many human feet, and secondary damage off-site. The methods do not work well in all circumstances. For example, low pressure flushing is ineffective on weathered, firmly-adhering oil on rocks and bioremediation is ineffective for sub-surface oil in poorly aerated sediments.

Physical removal of bulk oil, or ‘free oil’ from shores e.g. by flushing or washing can decrease damage by limiting the threat to some types of organisms, by reducing the likelihood of oil floating off and threatening other areas, and by averting the formation of asphalt pavements. However, shore clean-up can damage organisms such as mussels, winkles and barnacles. They may be trampled during any type of clean up activity or 'cooked' during hot water/ steam treatment.

Experiments carried out in Sweden in the early 1980s, together with experience in Alaska following the Exxon Valdez spill, have shown that high pressure, hot water washing is particularly damaging to shore algae and invertebrates. Nevertheless, it may still be justifiable (as was argued in Alaska) if it minimises the threat to birds and mammals that use the shore.

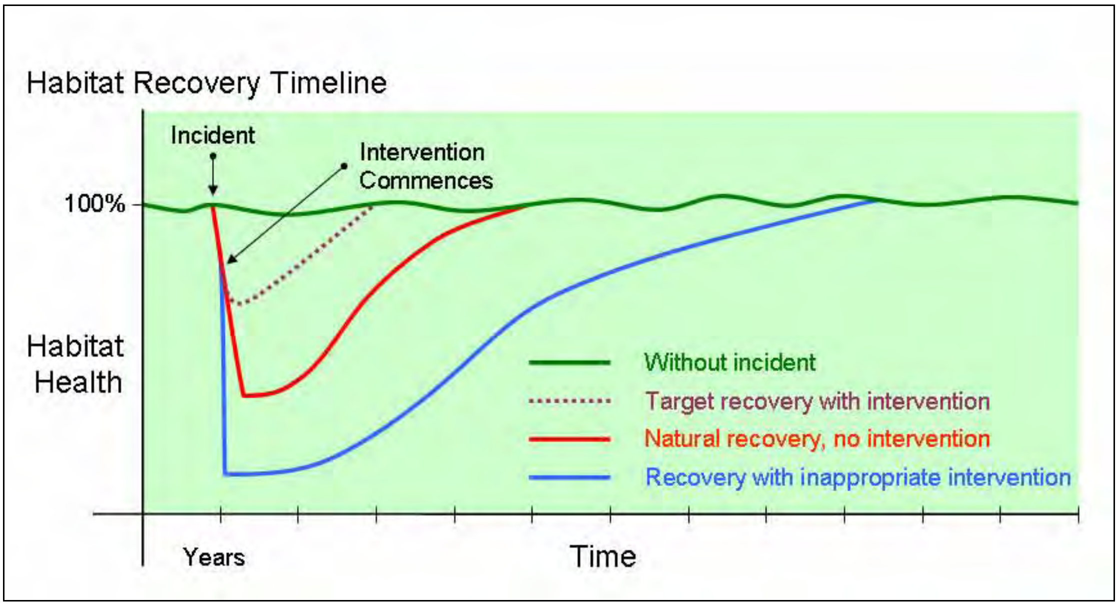


Figure 5.1 shows a hypothetical scenario for the recovery of an area of wetland, such as salt-marsh, a low energy area that is an important habitat for a wide variety of ecological resources including avian cover and prey production, fish spawning and rearing, and shoreline protection.

The removal of residual oil, e.g. stains, weathered crusts or oil buried in sediment may be controversial because some people approach the problem from an aesthetic point of view and others from a biological point of view. Biologically there seems little point in disturbing the shore to remove such residues if recovery of flora and fauna is progressing (which is usually the case). It might be justified however, if residual oil is hindering recovery.

Aggressive methods of shore cleaning (those that are likely to damage shore structure and/or shore organisms at least in the short term) include:

- Sediment relocation, i.e. moving sand or coarser sediments down the beach where they receive greater natural cleaning by wave action;
- Removal of shore material such as sand, stones, or oily vegetation together with underlying roots and mud. (In some cases the material may be washed and returned to the shore);
- Water flushing at high pressure and/or high temperature;
- Sand blasting

Below are some examples of NEBA consideration on oiled shorelines (Table 5.2).

Table 5.2. Examples of NEBA consideration on oiled shorelines

NEBA consideration	oiled shorelines
Heavily oiled shoreline with oil stranded on the upper shore running down through the intertidal and therefore re-mobilising. This is a clear candidate for clean-up under NEBA.	
Bulk (gross) oil on this amenity beach undergoing mechanical and manual clean-up. These actions are justified under NEBA, as the beach is of relatively low conservation interest and very high tourist interest. All efforts to remove the bulk oil are justified, although the trenching did cause some problems in the long term as some oil became buried.	
Leaching is particularly a problem from oil that has penetrated a beach (e.g. pebbles). The sheen may be an aesthetic problem or cause contamination of shallow water filter feeders, such as shellfish. A consideration of the use of the area is needed in making a decision whether it will bring benefit to clean the shore to a level where leaching does not occur. Note that such cleaning can be timing consuming and difficult.	
Taking shoreline clean-up to the level of sieving sand for small tar balls may be justifiable if these balls will adhere to the clothes or footwear of recreational beach users. This will depend on the public profile of the beach, the time of year and the exposure to wave action.	

	
Using aggressive techniques on natural shorelines requires much greater consideration. It is very difficult to ascertain the net benefit from this clean-up. This may remove some oil, but is likely to disturb the ecology more than the existing pollution. Natural clean-up is probably the best option for such a remote and inaccessible location.	

However, we cannot look at the biological and ecological affects of the different response options in isolation: the type of shoreline; the oil characteristics – smothering or toxic; the level of oiling – quantity and coverage; the length of time that the oil remains in contact with the sensitive resource and the response options for different shoreline types also need to be considered.

5.3 Shoreline Types in the Barents and White Seas and Response Considerations

The different shoreline types which can be encountered in and around the Barents and White seas are listed below. A fuller description of the shoreline type, predicted oil behaviour and cleanup response options are detailed in Table 5.2.

- Exposed rocky shore;
- Exposed wave-cut platforms;
- Fine-grained sand beaches;
- Medium to coarse-grained sand beaches;
- Mixed sand and gravel beaches;
- Gravel beaches;
- Riprap;
- Exposed tidal flats;
- Sheltered rocky shores;
- Sheltered, solid man-made structures;
- Salt water marshes.

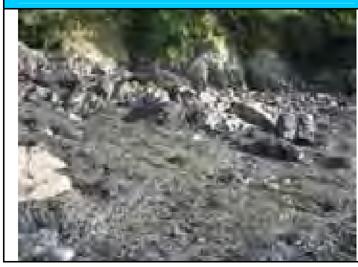
Table 5.2. Shoreline descriptions including oil behaviour and response considerations

1.	**Exposed Rocky Shore**
	– The intertidal zone, often steep with very little width; – Sediment accumulations are uncommon and usually ephemeral, because waves remove the debris that has slumped from the eroding cliffs; – There is strong vertical zonation of intertidal biological communities; – Species density and diversity vary greatly.
Predicted Oil Behaviour	– Oil is held offshore by wave reflecting off the shore; – Any oil that is deposited is rapidly removed from exposed faces; – The most resistant oil would remain as a patchy band at or above the high-tide line; – Impacts to intertidal communities are expected to be short-term in duration. An exception would be where heavy concentrations of a light refined product came ashore very quickly.
Response Considerations	– Cleanup is usually not required; – Access can be difficult and dangerous.
2.	**Exposed Wave-cut Platforms**
	– The intertidal zone consists of a flat rock bench of highly variable width; – The shoreline may be backed by a steep scarp or low bluff; – There may be a beach of sand- to boulder-sized sediments at the base of the scarp; – The platform surface is irregular and tidal pools are common; – Small amounts of gravel can be found in the tidal pools and crevices in the platform; – These habitats can support large populations of encrusting animals and plants, with rich tidal pool communities.
Predicted Oil Behaviour	– Oil will not adhere to the rock platform, but rather be transported across the platform and accumulate along the high-tide line; – Oil can penetrate in beach sediments, if present; – Persistence of oiled sediments is usually short-term, except in wave shadows or where the oil has penetrated sediments at the high-tide line.
Response Considerations	– Cleanup is usually not required; – Where the high-tide area is accessible, it may be feasible to remove heavy oil accumulations and oiled debris.
3.	**Fine-Grained Sand Beaches**

	– These beaches are generally flat and hard-packed – Though they are predominately fine sand, there is often a small amount of shell hash – There can be heavy accumulations of wrack present – They are utilized by birds for nesting and feeding – Upper beach fauna are generally sparse, although amphipods can be abundant; lower beach fauna can be moderately abundant, but highly variable
Predicted Oil Behaviour	– Light oil accumulations will be deposited as oily bands along the upper intertidal zone – Heavy oil accumulations will cover the entire beach surface; oil will be lifted off the lower beach with the rising tide – Maximum penetration of oil into fine-grained sand is about 10 cm – Burial of oiled layers by clean sand within the first week after a spill typically will be less than 30 cm along the upper beach face – Organisms living in the beach sediment may be killed by smothering or lethal oil concentrations in the interstitial water – There may be declines in infauna, which can affect important shorebird foraging areas
Response Considerations	– These beaches are among the easiest shoreline types to clean; – Cleanup should concentrate on removing oil and oily debris from the upper swash zone once oil has come ashore; – Activity through oiled and dune areas should be limited, to prevent oiling of clean areas; – Manual cleanup, rather than road graders and front-end loaders, is usually advised to minimize the volume of sand removed from the shore and requiring disposal; – All efforts should focus on preventing the mixture of oil deeper into the sediments by vehicular and foot traffic; – Mechanical reworking of lightly oiled sediments from the high-tide line to the upper intertidal zone can be effective along outer beaches.
4.	**Medium to Coarse-grained Sand Beaches**
	– These beaches have relatively steep beach faces and soft substrates; – Coarse-sand beaches can undergo rapid erosion/deposition cycles, even within one tidal cycle; – The amount of vegetation/seaweed varies considerably; – They are utilized by birds for nesting and feeding.
Predicted Oil Behaviour	– Light oil accumulations will be deposited as oily bands along the upper intertidal zone; – Heavy oil accumulations will cover the entire beach surface, oil will be lifted off the lower beach with the rising tide; – Maximum oil penetration is about 20 cm; – Burial of oiled layers by clean sand within the first week after a spill can be up to 50 cm; – Organisms living in the beach sediments may be killed by

	smothering or lethal oil concentrations in the interstitial water; – There may be declines in infauna, which can affect important shorebird foraging areas.
Response Considerations	– Coarse sand sediments are less trafficable, increasing the risk of mixing oil into the substrate by foot and vehicular traffic; – Cleanup should concentrate on removing oil and oily debris from the upper swash zone once oil has come ashore; – Traffic through oiled and dune areas should be limited, to prevent oiling of clean areas; – Manual cleanup, rather than road graders and front-end loaders, is advised to minimize the volume of sand removed from the shore and requiring disposal; – All efforts should focus on preventing the mixture of oil deeper into the sediments by vehicular and foot traffic; – Mechanical reworking of lightly oiled sediments from the high-tide zone to the upper intertidal zone can be effective along outer beaches.
5.	**Mixed Sand and Gravel Beaches**
	– These beaches are moderately sloping and composed of a mixture of sand and gravel; – Because of the mixed sediment sizes, there may be zones of pure sand, pebbles, or cobbles; – There can be large-scale changes in the sediment distribution patterns depending upon season, because of the transport of the sand fraction offshore during storms; – Because of sediment desiccation and mobility on exposed beaches, there are low densities of attached animals and plants; – The presence of attached algae and animals indicates beaches that are relatively sheltered, with the more stable substrate supporting a richer biota.
Predicted Oil Behaviour	– During small spills, oil will be deposited along and above the high-tide swash; – Large spills will spread across the entire intertidal area; – Oil penetration into the beach sediments may be up to 50 cm; however, the sand fraction can be quite mobile, and oil behaviour is much like on a sand beach if the sand exceeds 40 percent; – Burial of oil may be deep at and above the high-tide line, where oil tends to persist, particularly where beaches are only intermittently exposed to waves; – In sheltered pockets on the beach, pavements of asphalted sediments can form if there is no removal of heavy oil accumulations, because most of the oil remains on the surface; – Once formed, these asphalt pavements can persist for many years; – Oil can be stranded in the coarse sediments on the lower part of the beach, particularly if the oil is weathered or emulsified.
Response Considerations	– Remove heavy accumulations of pooled oil from the upper beach face;

	– All oiled debris should be removed; – Sediment removal should be limited as much as possible; – Low-pressure flushing can be used to float oil away from the sediments for recovery by skimmers or sorbents. High-pressure spraying should be avoided because of potential for transporting contaminated finer sediments (sand) to the lower intertidal or sub-tidal zones; – Relocation of oiled sediments from the high-tide zone to the upper intertidal zone can be effective in areas regularly exposed to wave activity (as evidenced by storm berms). However, oiled sediments should not be relocated below the mid-tide zone; – Tilling may be used to reach deeply buried oil layers in the middle zone on exposed beaches.
6.	**Gravel Beaches**
	– Gravel beaches are composed of sediments ranging in size from pebbles to boulders. The gravel-sized sediments can be made up of shell fragments; – They can be very steep, with multiple wave-built berms forming the upper beach; – Attached animals and plants are usually restricted to the lowest parts of the beach, where the sediments are less mobile; – The presence of attached algae, mussels, and barnacles indicates beaches that are relatively sheltered, with the more stable substrate supporting a richer biota.
Predicted Oil Behaviour	– Deep penetration and rapid burial of stranded oil is likely on exposed beaches; – On exposed beaches, oil can be pushed over the high-tide and storm berms, pooling and persisting above the normal zone of wave wash; – Long-term persistence will be controlled by the depth of penetration versus the depth of routine reworking by storm waves; – On the more sheltered portions of beaches, formation of asphalt pavements is likely where accumulations are heavy.
Response Considerations	– Heavy accumulations of pooled oil should be removed quickly from the upper beach; – All oiled debris should be removed; – Sediment removal should be limited as much as possible; – Low- to high-pressure flushing can be used to float oil away from the sediments for recovery by skimmers or sorbents; – Relocation of oiled sediments from the high-tide zone to the upper intertidal zone can be effective in areas regularly exposed to wave activity (as evidenced by storm berms). However, oiled sediments should not be relocated below the mid-tide zone; – Tilling may be used to reach deeply buried oil layers in the upper to-mid-tide zone on exposed beaches.
7.	**Riprap**

	– Riprap is composed of cobble-to boulder-sized blocks of granite, limestone, or concrete; – Riprap structures are used for shoreline protection and channel stabilization (jetties); – Attached biota is sparse.
Predicted Oil Behaviour	– Oil adheres readily to the rough surfaces of the blocks; – Deep penetration of oil between the blocks is likely; – Un-cleaned oil can cause chronic leaching until the oil solidifies.
Response Considerations	– When the oil is fresh and liquid, high pressure flushing and/or water flooding may be effective, making sure to recover all liberated oil; – Heavy and weathered oils are more difficult to remove, requiring scrapping and/or hot-water flushing; – In extreme cases, it may be necessary to remove heavily oiled blocks and replace them.
8.	**Exposed Tidal Flats**
	– Exposed tidal flats are broad intertidal areas composed primarily of sand and minor amounts of shell and mud; – The dominance of sand indicates that currents and waves are strong enough to mobilize the sediments; – They are usually associated with another shoreline type on the landward side of the flat, though they can occur as separate shoals; they are commonly associated with tidal inlets; – Biological utilization can be very high, with large numbers of infauna, heavy use by birds for roosting and foraging, and use by foraging fish.
Predicted Oil Behaviour	– Oil does not usually adhere to the surface of exposed tidal flats, but rather moves across the flat and accumulates at the high-tide line; – Deposition of oil on the flat may occur on a falling tide if concentrations are heavy; – Oil does not penetrate water-saturated sediments; – Biological damage may be severe, primarily to infauna, thereby reducing food sources for birds and other predators.
Response Considerations	– Currents and waves can be very effective in natural removal of the oil; – Cleanup is very difficult (and possible only during low tides); – The use of heavy machinery should be restricted to prevent mixing of oil into the sediment.
9.	**Sheltered Rocky Shores**
	– These are bedrock shores of variable slope (from vertical cliffs to wide, rocky ledges) that are sheltered from exposure to most wave and tidal energy; – Wide shores may have some surface sediments, but bedrock is the dominant substrate type; – Species density and diversity vary greatly, but biota are often very abundant.

Predicted Oil Behaviour	– Oil will adhere readily to the rough rocky surface, particularly along the high-tide line, forming a distinct oil band; – Even on wide ledges, the lower intertidal zone usually stays wet (particularly when algae covered), preventing oil from adhering to the rock surface; – Heavy and weathered oils can cover the upper zone with little impacts to the rich biological communities of the lower zone; – Where surface sediments are abundant, oil will penetrate into the crevices formed by the surface rubble, forming persistent pavements; – Where the rubble is loosely packed, oil will penetrate deeply, causing long-term contamination of the subsurface sediments.
Response Considerations	– Low-pressure flushing at ambient temperatures is most effective when the oil is fresh; – Extreme care must be taken not to spray in the biologically rich lower intertidal zone or when the tidal level reaches that zone; – Cutting of oiled, attached algae is not recommended; tidal action will eventually float this oil off, so sorbent booms should be deployed.
10.	**Sheltered, Solid Man-made Structures**
	– These structures are solid man-made structures such as seawalls, groins, revetments, piers, and port facilities; – Most structures are constructed of concrete, wood, or metal, and their composition, design, and condition are highly variable; – Often there is no exposed beach at low tide, but a wide variety of habitats may be present; – Attached animal and plant life can be moderate to high.
Predicted Oil Behaviour	– Oil will adhere readily to the rough surface, particularly along the high-tide line, forming a distinct oil band; – The lower intertidal zone usually stays wet (particularly if algae covered), preventing oil from adhering to the surface.
Response Considerations	– Cleanup of seawalls is usually conducted for aesthetic reasons or to prevent leaching of oil; – Low- to high-pressure flushing at ambient water temperatures is most effective when the oil is fresh. Hot water is needed for heavy or weathered oils.
11.	**Sheltered Tidal Flats**
	– Sheltered tidal flats are composed primarily of mud with minor amounts of sand and shell; – They are present in calm-water habitats, sheltered from major wave activity, and are frequently backed by marshes; – The sediments are very soft and cannot support even light foot traffic in many areas; – They can be sparsely to heavily covered with algae and/or seagrasses; – They can have very heavy wrack accumulations along the high-tide line; – There can be large concentrations of shellfish, worms, and

	snails on and in the sediments; – They are heavily utilized by birds and fish for feeding.
Predicted Oil Behaviour	– Oil does not usually adhere to the surface of sheltered tidal flats, but rather moves across the flat and accumulates at the high-tide line; – Deposition of oil on the flat may occur on a falling tide if concentrations are heavy; – Oil will not penetrate the water-saturated sediments, but could penetrate burrows and root cavities; – Biological damage may be severe.
Response Considerations	– These are high-priority areas for protection since cleanup options are very limited; – Cleanup is very difficult because of the soft substrate; many methods may be restricted; – Deluge flooding and deployment of sorbents from shallow-draft boats may be helpful.
12.	**Salt Water Marshes**
	– These marshes contain vegetation which tolerates water salinity down to about 5 ppt; – Width of the marsh can vary widely, from a narrow fringe to extensive areas; – Sediments are composed of organic-rich muds except on the margins of barrier islands where sand is abundant; – Exposed areas are located along water-bodies with wide fetches and along busy waterways; – Sheltered areas are not exposed to significant wave or boat wake activity; – Resident flora and fauna are abundant with numerous species with high utilization by birds, fish, and shellfish.
Predicted Oil Behaviour	– Oil adheres readily to intertidal vegetation; – The band of coating will vary widely, depending upon the water level at the time oil slicks are in the vegetation. There may be multiple bands; – Large slicks will persist through multiple tidal cycles and coat the entire stem from the high-tide line to the base; – If the vegetation is thick, heavy oil coating will be restricted to the outer fringe, although lighter oils can penetrate deeper, to the limit of tidal influence; – Medium to heavy oils do not readily adhere to or penetrate the fine sediments, but can pool on the surface or in burrows and root cavities; – Light oils can penetrate the top few centimetres of sediment and deeply into burrows and mud cracks (up to one meter).
Response Considerations	– Under light oiling, the best practice is to let the area recover naturally; – Natural removal processes and rates should be evaluated prior to conducting cleanup; – Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing. During flushing, care must be taken to prevent transporting oil to sensitive areas down slope or along shore; – Cleanup activities should be carefully supervised to avoid vegetation damage; – Any cleanup activity must not mix the oil deeper into the

	sediments. Trampling of the roots must be minimized; – Cutting of oiled vegetation should only be considered when other resources present are at great risk from leaving the oiled vegetation in place.

Snow is common on all arctic and cold-climate shorelines. The behaviour and spreading of oil on a snow covered shoreline depends on: the type of snow; the air temperature and; the surface character of the shore (flat or sloping), however, the following is a general rule of thumb:

- Oil stranded on a snow-covered shore likely would be partially contained by the snow, which is a good, natural oil sorbent.
- Oil-snow proportions depend on the oil type and the snow character with the oil content being highest for medium crudes rather than for light products.
- Oil content is lowest on firm compacted snow surfaces in below-freezing temperatures and highest for fresh snow conditions.
- Oil causes snow to melt. Crude oils cause more melting but spread less than light oils, which moves more quickly in snow and over a larger area. Light oils can move upslope in snow through capillary action as they spread.
- Fresh snow that blows over oil tends to stick and migrate down into the oil, causing an increase in the volume of material to be recovered.
- Snow falling onto oil tends to accumulate on the oil surface.

Based on the analysis of the cleanup response and its biological and physical affects (Table 5.1) and assessment of oil behaviour and response considerations on different shoreline types (Table 5.2) response strategy choice matrix was developed (Table 5.3). Optimal response options depending on the shoreline type are marked as V.

Table 5.3. Strategy Choice Matrix

Shoreline type / Response option	Offshore	Exposed rocky shore	Exposed wave-cut platforms	Fine-grained sand beaches	Medium to coarse-grained sand beaches	Mixed sand and gravel beaches	Gravel beaches	Riprap	Exposed tidal flats	Sheltered rocky shores	Solid man-made structures	Salt water marshes	Snow and Ice
Monitor and Evaluate (Offshore)	V												V
Containment and Recovery	V												V
Natural Recovery		V	V	V	V	V	V	V	V	V	V	V	N
Mechanical removal		-	-	-	-	-	-	V	-	-	-	N	V
Manual removal/cleaning		-	-	V	V	-	-	-	-	-	-	-	V
Vacuum tanks /trucks		V	V	V	V	V	V	V	-	V	V	-	V
Sea water flooding		V	-	N	N	N	V	V	-	V	V	-	-
Low pressure ambient flushing		V	V	N	N	N	V	V	-	V	V	N	-
High pressure ambient washing		VE	VE	N	N	N	N	V	-	VE	V	-	-
High pressure hot water washing		VE	-	N	N	N	N	V	-	VE	V		-
Vegetation cutting /		-	-	-	-	-	-	-	-	-	-	VE	-

removal													
Berm replacement		-	-	VL	VL	VL	VL	-	-	-	-	-	-
Steam cleaning		VE	-	-	-	-	N	V	-	-	V	-	-
Sand blasting		VE	-	-	-	-	N	V	-	VE	V	-	-
Sediment tilling		-	-	V	V	V	N	-	-	-	-	-	-

- Not a viable option for consideration (due to practical or environmental reasons)
V This is a viable option for consideration
VE This is a viable option, but is likely to result in increased environmental damage
VL This is a viable option for light oiling
N This option should not be used as it is likely to result in significant damage

Summarizing results of NEBA of applying various emergency oil spill response methods in the Barents and White seas optimal response options are recommended to be applied in the modeling scenarios (Table 5.4).

Table 5.4. Recommended response options in the oil spill scenarios

No.	scenario	oil fate	type of impacted shoreline	recommended response options
Scenarios group Aut-S-1				
1.	COV-Aut-S-1	strands ashore, drifts to open waters	open water	- monitor and evaluate - containment and recovery
2.	BO-Aut-S-1		exposed rocky shore	- natural recovery - vacuum (for pooled oil) - seawater flooding - low pressure ambient flushing
3.	GC-Aut-S-1		open water	- monitor and evaluate
4.	Na-Aut-S-1		exposed rocky shore	- natural recovery
Scenarios group Aut-SW-1				
5.	COV-Aut-SW-1	drifts to open waters	-	- monitor and evaluate
6.	BO-Aut-SW-1			
7.	GC-Aut-SW-1			
8.	Na-Aut-SW-1			
Scenarios group Spr-N-1				
9.	COV-Spr-NW-1	strands ashore	exposed rocky shore	- natural recovery - vacuum (for pooled oil) - seawater flooding - low pressure ambient flushing
10.	BO-Spr-NW-1		mixed sand and gravel beaches	- natural recovery - vacuum (for pooled oil) - berm replacement (for light oiling)
11.	GC-Spr-NW-1		exposed rocky shore	- natural recovery
12.	Na-Spr-NW-1		mixed sand and gravel beaches	- natural recovery - berm replacement
Scenarios group Spr-NW-1				
13.	COV-Spr-NW-1	strands ashore	exposed rocky shore	- natural recovery - vacuum (for pooled oil) - seawater flooding - low pressure ambient

				flushing
14.	BO-Spr-NW-1		mixed sand and gravel beaches	- natural recovery - vacuum (for pooled oil) - berm replacment (for light oiling)
15.	GC-Spr-NW-1		exposed rocky shore	- natural recovery
16.	Na-Spr-NW-1		mixed sand and gravel beaches	- natural recovery - berm replacement
Scenarios group Aut-S-2				
17.	COU-Aut-S-2	strands ashore	mixed sand and gravel beaches	- natural recovery - vacuum (for pooled oil) - berm replacement (for light oiling)
18.	BO-Aut-S-2		seagrass	- natural recovery
19.	GC-Aut-S-2			
20.	Na-Aut-S-2	dissipates naturally	open water	- monitor and evaluate
Scenarios group Aut-W-2				
21.	COU-Aut-W-2	strands ashore	tidal flats with clay cliffs	- natural recovery
22.	BO-Aut-W-2		fine to medium grained sandy beaches	- natural recovery - manual cleaning - vacuum (for pooled oil) - berm replacement (for light oiling)
23.	GC-Aut-W-2			
24.	Na-Aut-W-2	dissipates naturally	open water	- monitor and evaluate
Scenarios group Win-S-2				
25.	COU-Win-S-2	frozen in ice	-	- monitor and evaluate - containment and recovery - vacuum tanks
26.	BO-Win-S-2			
27.	GC-Win-S-2			
28.	Na-Win-S-2			
Scenarios group Win-W-2				
29.	COU-Win-W-2	frozen in ice	-	- monitor and evaluate - containment and recovery - vacuum
30.	BO-Win-W-2			
31.	GC-Win-W-2			
32.	Na-Win-W-2			

5.4 CONCLUSIONS

The starting point for understanding Net Environmental Benefit Analysis (NEBA) is an acceptance that both spilled oil and clean-up activity can have adverse ecological and socio-economic effects. The NEBA framework is simply described as making informed decisions about whether to respond, with regard to overall possible environmental consequences. The reference point is that of natural clean-up, against which, the likely results of intervention (i.e. response actions, clean-up and/or restoration) may be measured. Carefully consideration needs to be given to whether a) to clean-up and b) which techniques to use. The key questions that help address these issue are:

- Severe (gross) oiling is likely to require clean-up efforts in most cases, not least because of the potential for remobilization and further contamination into currently unaffected areas;

- If an area is used by animals for breeding, roosting, haul-out etc., there is likely to be concern to get the area to return to its pre-incident condition as soon as possible;
- Socio-economic factors can also be a very good reason for carrying out clean-up but be aware that there may be media/public pressure to clean-up because there is a need 'to be seen to be doing something'.

Implicit in the process is the acceptance that, in many circumstances there has to be a recognition that damage will occur from oil spills. The level of damage should be seen in relation to the ability of the damaged area to recover, sometimes measured in a time span. Furthermore some intervention may cause further damage, but in the overall picture this should be done in a way which results in the least damage; the net benefit to the environment. Whilst this sounds obvious, there have been frequent examples where well-intentioned clean-up has actually exacerbated the overall damage.

NEBA is often regarded as a complex scientific process, however it should not be seen solely as such. Factors such as plain common sense and local stakeholder expectations are just as important. The process does require some basic elements, including information concerning what ecological and socio-economic resources are threatened and how they may be affected, and what response techniques are feasible. NEBA encourages information gathering and inclusive discussions with stakeholders during contingency planning, which is when the broad NEBA framework should be established.

There can be a large reliance on expert opinion and documentation from previous incidents and studies to help with the NEBA process. However the reliability of these sources of information should be measured against the difficulty to continually monitor progress of recovery; the lack of baseline information; difficulty in monitoring natural recovery of individual species – scientist do this but it takes a number of years; other factors may affect natural fluctuation and; practical considerations of the types of cleanup that were previously employed during the response.

It may require a process of education for a number of stakeholders, to explain the ability of the environmental to survive and assimilate accidental oil spills and there is a significant body of evidence, to reassure that nature can be effective in cleaning up - in many instances.

In the Barents and White seas, it is very challenging to combat large spills offshore. Although the preferred option may be to contain and recover the oil, there are many reasons why success will often be poor. It may be justifiable to simply observe the slicks and await natural dissipation, particularly if the oil is away from coasts and a type that does readily break-down.

6 DEVELOPMENT OF DECISION-MAKING ALGORITHM FOR THE SELECTION OF THE OIL SPILL RESPONSE TECHNIQUES BY THE RUSSIAN EMERGENCY RESPONSE AGENCIES, PORT AUTHORITIES AND OTHER SPECIALIZED UNITS

6.1 Analysis of the Existing Interaction between the Russian Agencies with regard to Response to Local, Regional or Federal Level Oil Spills Prior to the Selection of the Oil Spill Response Technique

6.1.1 Functions and Powers of the Federal Authorities and Specialized Russian Agencies in Oil Spill Response

In accordance with the legislation of the Russian Federation the oil spill response is effected through a coordinated effort of federal authorities, organizations and services tasked with emergency response functions including response to oil spills. The responsibilities in emergency response operations, including oil spills, must be clearly defined for all participants of an oil spill response operation (Federal Law No. 68-FZ of 21.12.1994).

In case of an oil spill The Ministry of Emergency of the Russian Federation coordinates activities of all federal authorities involved in oil spill response through the Government Commission on Emergency Prevention and Emergency Relief. The Government Commission sets up a Federal Operational Command (FOC) at the State Maritime Rescue Coordination Centre (SMRCC) of Russia's State Maritime Rescue Service. The FOC is made up of members of the Government Commission as well as senior officials of federal authorities. The FOC develops and accepts recommendations for the marine oil spill response which are then approved by the Government Commission.

The Russian Maritime and River Transport Agency of the Russian Ministry of Transport through the State Maritime Rescue Service and its regional departments (BASUs) organizes and carries out marine oil spill response operations (RF Government Resolution No. 240 of 15.04.02, Decree of the Ministry of Transport No. 53 of 06.04.09). The FOC commands the emergency response operation on the shore within the framework of the Russian Emergency Response and Emergency Relief System.

The FOC is headed by Deputy Minister of Civil Defence, Emergencies and Elimination of Consequences of Natural Disasters of the Russian Federation. Deputy heads of the FOC are:

- First Deputy Minister of Transport;
- Head of the State Maritime Rescue Service:
- Deputy Minister of the Ministry of Natural Resources;
- Head of federal support of territories department of Ministry of Civil Defence, Emergencies and Disaster Relief;
- Deputy Chairman of the Russian Fisheries Agency (Rosrybolovstvo).

The FOC includes authorized representatives of the Ministry of Defence, Ministry of Natural Resources, the Federal Security Service, the Ministry of Transport, the Fisheries Agency, the State Maritime Rescue Service, the Federal Service for the Oversight of Consumer Protection and Welfare of the Russian Ministry of Healthcare and Social Development (Rospotrebnadzor), Russian Hydrometeorological Service (Rosgidromet) and National Centre of Operation Control in ES of the Ministry of Civil Defence, Emergencies and Elimination of Consequences of Natural Disasters (NCCES).

The FOC temporarily includes a representative of the owner of the vessel which caused the oil spill. He provides information on the vessel, participates in the development of the operations plan and addresses the issues pertaining to the recovery of costs of the oil spill response operation.

The FOC brings in experts in various fields such as national and international law, economics, environment, fish protection, fisheries, oil containment and collection, hydrometeorology and weather forecasting, oil distribution and migration, oil sampling and analysis, shoreline protection, elimination and disposal of irreprocessible oil containing materials and aerial observation.

During an oil spill response operation the federal authorities command their facilities and resources and perform functions described in Table 6.1:

Table 6.1. Federal authorities' functions in oil spill response

Federal authority	Oil spill response function
Ministry of Civil Defence, Emergencies and Elimination of Consequences of Natural Disasters	– Coordinates activities of federal authorities and presents an oil spill response operations plan for approval; – Participates in the activities and in the air transport support of the delivery of oil spill response resources from other regions to the area of the spill.
The Russian Maritime and River Transport Agency (Rosmorrechflot)	– Develops an oil spill response operations plan and determine the need for facilities and resources from other regions; – Ensures transportation of oil spill response facilities and resources from other regions to the area of the spill; – Performs operational command of top-priority activities; – Participates in the inspection and prediction of the oil spill behaviour.
State Maritime Rescue Service of Russia	– Participates in the development of an oil spill response operations plan; – Ensures allocation of vessels for the oil spill response; – Coordinates deployment of facilities and resource of a regional salvage department to the area of the spill; – Organizes immediate control and oil spill response activities.
Ministry of Natural Resources	– Participates in the development of the oil spill response operations plan with respect to minimizing impact on the environment and marine natural resources; – Participates in the determination of the cause of the spill; – Participates in the selection of oil spill response technique; – Evaluates the risk of pollution of priority protection zones; – Identifies the guilty polluter, issues required documentation and takes administrative measures in respect of the polluter; – Calculates environmental damage and seeks compensation.
Russian Fisheries Agency	– Liaises with administrations of fish terminals, fishing companies and fish protection authorities; – Ensures allocation and coordinates activities of oil spill response facilities and resources of the Russian Fisheries Agency; – In accordance with the Federal Oil Spill Response Plan prepares proposals for relocation of crews and equipment from other regions; – Participates in the selection of the oil spill response technique; – Participates in the development of the oil spill response operations plan with respect to minimizing impact on the environment and live resources; – Participates in calculation of damage to living resources; – Participates in the determination and investigation of oil spill causes.
Frontier Service of the Federal Security Service	– Ensures allocation and redeployment of its own facilities and resources to the oil spill area for the investigation and monitoring of the oil spill drift;

	– Controls compliance with established rules for temporary navigation hazardous areas in internal sea waters and territorial sea and guards these areas; – Ensures implementation of measures adopted by the RF government with the aim to protect the coast of the Russian Federation or associated interests (including fisheries) from pollution or pollution hazard in case of maritime accidents in the exclusive economic zone; – Issues permits for the crossing of the RF state border to emergency teams of other states in accordance with the established procedure – Participates in the investigation of oil pollution of marine environment to recover compensation for harm inflicted upon the marine environment and living resources.
Ministry of Defence	– Ensures allocation and redeployment of the Ministry of Defence's facilities and resources for oil spill response and oil drift monitoring*. – Resolves issues of granting access to the Russian territorial waters to assisting foreign oil spill response vessels within its powers.
Federal Service for the Oversight of Consumer Protection and Welfare of the Ministry of Healthcare and Social Development (Rospotrebnadzor)	– Participates in the survey of the oil spill spread area; – Assesses the impact of the environmental pollution on public health and living conditions.
Russian Hydrometeorological Service (Rosgidromet)	– Ensures participation of Rosgidromet's units in the survey of the pollution levels in the oil spill area among others through sampling and analysis of the marine environment including shoreline; – Makes real-time forecast of the oil spill spread; – Provides the FOC with short-term and long-term forecasts, relevant hydro meteorological information and pollution data in the oil spill area.

**facilities and resources of the Ministry of Defence for oil spill response and monitoring are allocated by decision of the President of the Russian Federation*

6.1.2 Oil Spill Response Prior to the Selection of the Oil Spill Response Technique

Efficient oil spill response in interaction of federal authorities and specialized Russian agencies/services prior to the selection of the oil spill response technique is divided in two clear-cut stages (Руководство, 2002):

Stage 1 Notification;
Stage 2 Decision making.

1) Notification

The notification stage is needed to notify all parties that may be involved in an oil spill response operation. The notification of highest bodies of state authority is a top priority and a statutory requirement (Руководство, 2002)

In accordance with the established international practice in case of a marine oil spill the notification is executed in accordance with the "Procedures for collection and sharing of information in the field of public and territories' protection from natural and anthropogenic emergencies" (RF Government Resolution No.334 of 24.03.1997) and "Notification procedure in case of marine environmental pollution" (Инструкция, 1994) (Fig. 6.1).

The pollution of the marine environment is reported by masters of vessels or pilots of civilian aircraft in case of the spill is detected by an aircraft. The general principle of notification about marine environmental pollution is that masters of vessels situated in the internal sea and territorial waters of the Russian Federation as well as in the Russian economic zone must report the pollution of the marine environment in the following instances:

- Incident with the vessel or another facility/object that has resulted or may result in the outflow of oil and other hazardous substances
- Detection of oil and other hazardous substances' outflow from another vessel (regardless of the flag) or another facility/object in violation of international or national regulations in force;
- Detection of an oil spill in harbour waters

The vessel radios the information about the oil spill to the captain-coordinator on duty of the appropriate MRCC or MRSC and also to other concerned parties: ship owner, operator, P&I[14] club. The Barents and White seas are the area of responsibility of MRCC of the Murmansk Sea Port Administration and the Arkhangelsk MRSC (Fig. 6.2). In case an oil spill is detected by an aircraft the information is reported to the air traffic controller, who in turn passes it on to the MRCC and the Centre of Operation Control in Emergency Situations (CCES) of the main department of the Ministry of the Emergency Situations in the respective region.

MRCC (MRSC) passes information on the oil spill to:

- Regional Salvage Department (BASU);
- State Maritime Rescue Service via the SMRCC;
- Administration of the seaport;
- Regional bodies of the Ministry of Emergency Situations the regional CCES;
- Frontier Service of the Russian Federal Security Service;
- Regional emergency medicine centre;
- Regional department of Russian Hydrometeorological Service;
- Basin department of the Russian Fisheries Agency.

CRC of the regional department of the Ministry of Emergency Situations reports the oil spill to:

- Government of the respective Russian region;
- CCES of a regional centre of the Ministry of Emergency Situations;
- National Centre of Operation Control in Emergency Situations of the Ministry of Emergency Situations (NCCES);
- Regional department of the Ministry of Natural Resources;
- Regional department of Federal Service for the Oversight of Consumer Protection and Welfare (Rospotrebnadzor).

Based on the information from the regional CCES a deputy governor of the respective region makes a decision on convening the regional government's commission on emergency situations and fire safety and the regional operational command (ROC), which is based at the regional salvage department (BASU).

In case a large oil spill qualifies as a regional, federal or transboundary emergency the ROC requests the FOC to provide assistance via NCCES.

[14] P&I club is an International Society of Mutual Insurance of the shipowners' liability against the third parties (literally - protection & indemnity). P&I clubs cover the third party claims against the shipowners, when such claims are of private civil liability nature, i.e., property liability.

Upon receiving information of an oil spill of regional and federal level the Emergency Situations Minister makes a decision to convene the Government Commission (RF Government resolution No. 240 of 15.04.02).

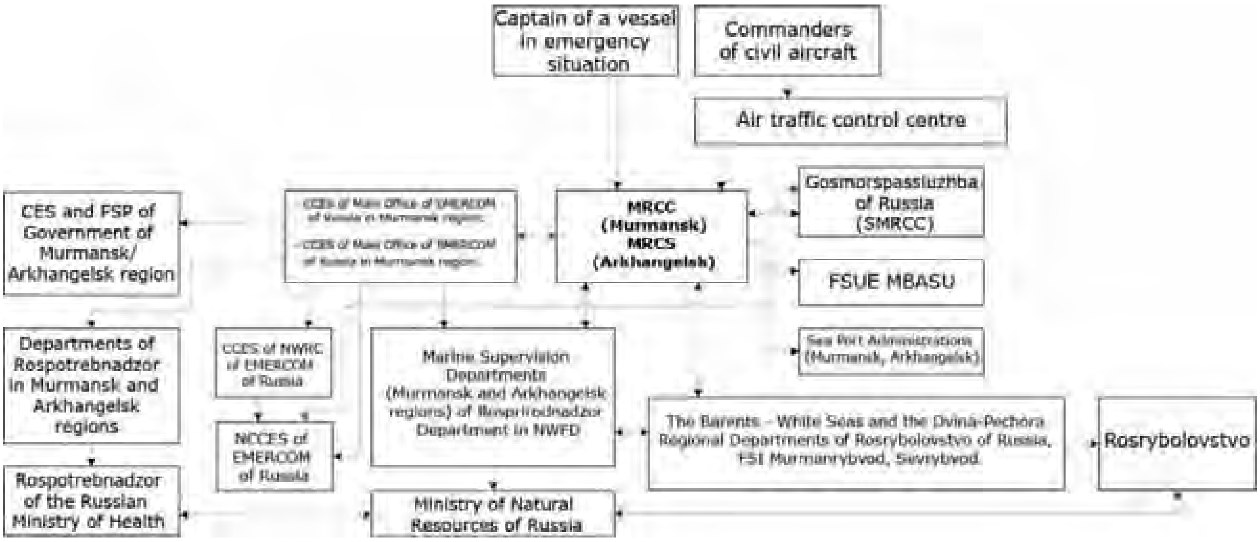


Fig.6.1. Oil spill notification sequence

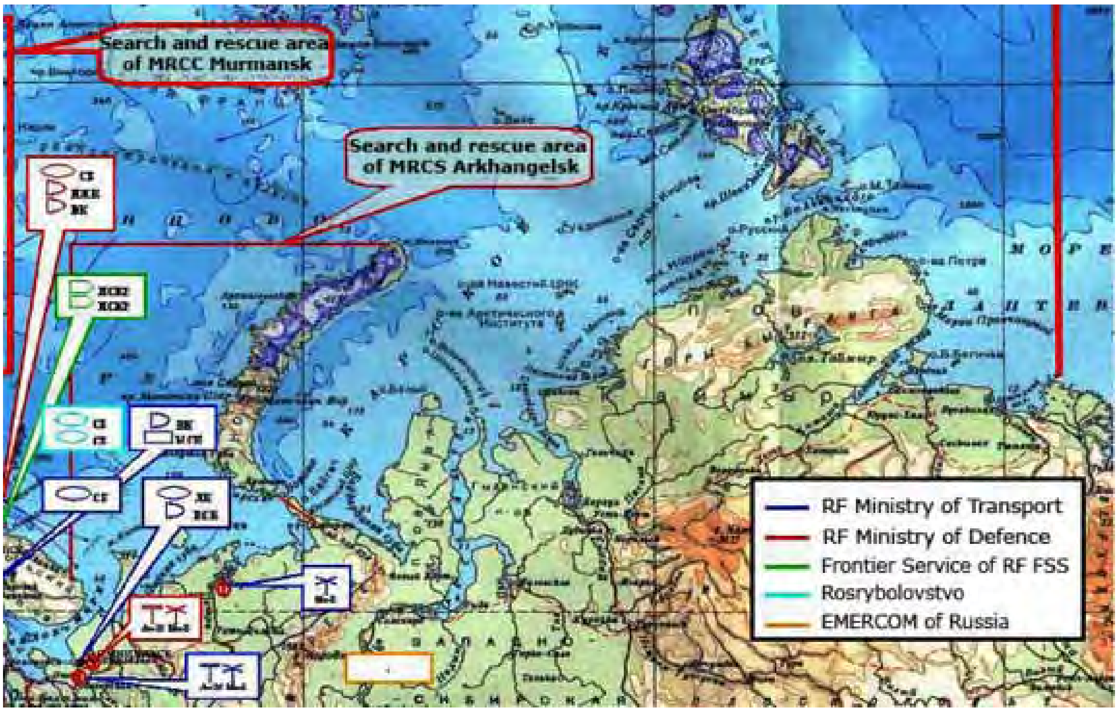


Fig. 6.2. The area of responsibility of the Murmansk MRCC and the Arkhangelsk MRSC

2) Decision making

Objective control of the oil spill response operation is achieved through a logical step-by-step decision-making process which is divided in the following stages (Руководство, 2002)

1. <u>Gather information</u>

Upon receiving information on the oil spill and a request for assistance from the ROC, head of the FOC through the NCCES verifies the information in order to determine the type and quantity of the pollutant, source of the spill and hazard to the public and the environment (Воробьев, Акимов, Соколов, 2005).

In the mean time immediately after receiving the notification "first wave" units are sent to the oil spill area. The FOC head appoints on-scene coordinators (OSC) for immediate command of the operation offshore and onshore, who move to the oil spill area.

Immediately upon receiving information on the spill an oil spread forecast system is activated to assess the necessity for protection of the shoreline and priority-protection zones. The FOC requests information on the actual weather and a weather forecast for the oil spill area from the hydrometeorological centre closest to the oil spill area.

The ROC organizes a tactical inspection of the spill area to characterize the spill. The results of the observation are documented. The documents are provided to the FOC for planning of the operation and use during the response effort. The Government Commission may appoint a task force comprising members of the FOC and relevant experts from ministries, agencies and organizations and send this task force to the oil spill area (RF Government resolution No. 240 of 15.04.02).

2. <u>Evaluate the situation</u>

Upon clarifying the information the FOC evaluates whether the emergency object or the regional centre are capable of responding to the oil spill with their own resources (Воробьев, Акимов, Соколов, 2005). The Russian Federation uses the following classification of marine oil spills (RF Government resolution No. 240 of 15.04.02):

- Local level oil spill – an oil spill in excess of the lower oil spill level (0.5 tons in the seas of the Arctic Ocean subject to NRM Order No. 156 of 03.03.03) and up to 500 tons. If a local spill occurs outside the area of responsibility of an oil handling facility, for example on a shipping lane, or if such a facility is unable to respond to the spill with its own resources, the responsibility for the response to oil spill is vested with the State Maritime Rescue Service.
- Regional level oil spill – from 500 to 5000 tons of oil. Response to the regional level oil spill requires involvement of facilities and resources located in the region. The responsibility for regional level oil spill response is vested with the State Maritime Rescue Service (Order of the Ministry of Transport No. 53 of 06.04.09).
- Federal level oil spill – over 5000 tons. Response to a federal level oil spill requires involvement of facilities and resources from other regions or neighbouring states. The Russian Agency of Maritime and River Transport of the Ministry of Transport is responsible for the immediate command of the oil collection operation at sea.
- Transboundary level oil spill – a spill extending beyond borders of the Russian Federation. The Russian Agency of Maritime and River Transport and appropriate national bodies of neighbouring states are charged with tactical command of the oil collection operation at sea.

Depending on the location of the spill and hydrometeorological conditions the category of the emergency may be upgraded (RF Government resolution No. 240 of 15.04.02, NRM Order No. 156 of 03.03.03). The procedure for evaluation of the level of the spill and decision making with regard to the response level is shown in Fig. 6.3.

Fig. 6.3. Procedure for oil spill level evaluation and response level decision making

3. Identify tasks of the oil spill response operation

At this stage the FOC and the ROC determine regional tasks of the response operation, determines national priorities and identify an acceptable level of environmental rehabilitation. As a rule the oil spill response operation includes the following tasks:

– Safety assurance during the oil spill response operation;
– Protection of the shoreline and sensitive resources;
– Minimization of pollution;
– Minimization of environmental damage;
– Waste minimization.

4. Develop strategies to address these tasks

At this stage a response strategy is developed in line with the tasks and priorities of the oil spill response operation.

5. Select an oil spill response technique for implementation of oil spill response strategies

At this stage oil spill response techniques are selected, including methods, approaches, operation modes, sequence of operations and procedures, equipment, tools and materials. The selection of an oil spill response technique is based on the characteristics of the spill and operational capabilities determined by facilities and resources that the FOC and the ROC have at their disposal as well as local conditions connected with the possibility to use mechanical, chemical and thermal oil recovery techniques. In selection of oil spill response techniques one must evaluate their usefulness, feasibility and safety for the staff involved in the operation.

6.2 Decision-Making Algorithm for Application of Oil Spill Response Techniques

In order to correctly evaluate the situation and make the right decision with regard to the selection of the oil spill response technique, the following information about the spill and relevant local conditions must be obtained during the information gathering and assessment stage:

- Location and scale of the spill;
- Properties of the spilt oil;
- Oil spread forecast;
- Environmental sensitivity of the coast in the spill area;
- Level of response and available resources;
- Distance from the spill to the nearest oil spill response base in order to determine the time of arrival of facilities and resources to spill site;
- Actual whether conditions and forecast for the coming 6, 12, 24 and 48 hours;
- Availability of transport infrastructure in the oil spill area for deployment of onshore response stations.

The ROC and the FOC analyze acquired information and select oil spill response techniques based on the analysis and evaluation of the situation. Experts of concerned ministries and agencies and oil spill response experts are involved in the selection process. Based on the analysis conducted in the previous chapters of this report, the following algorithm of decision-making regarding application of oil spill response techniques has been developed (Fig. 6.4).

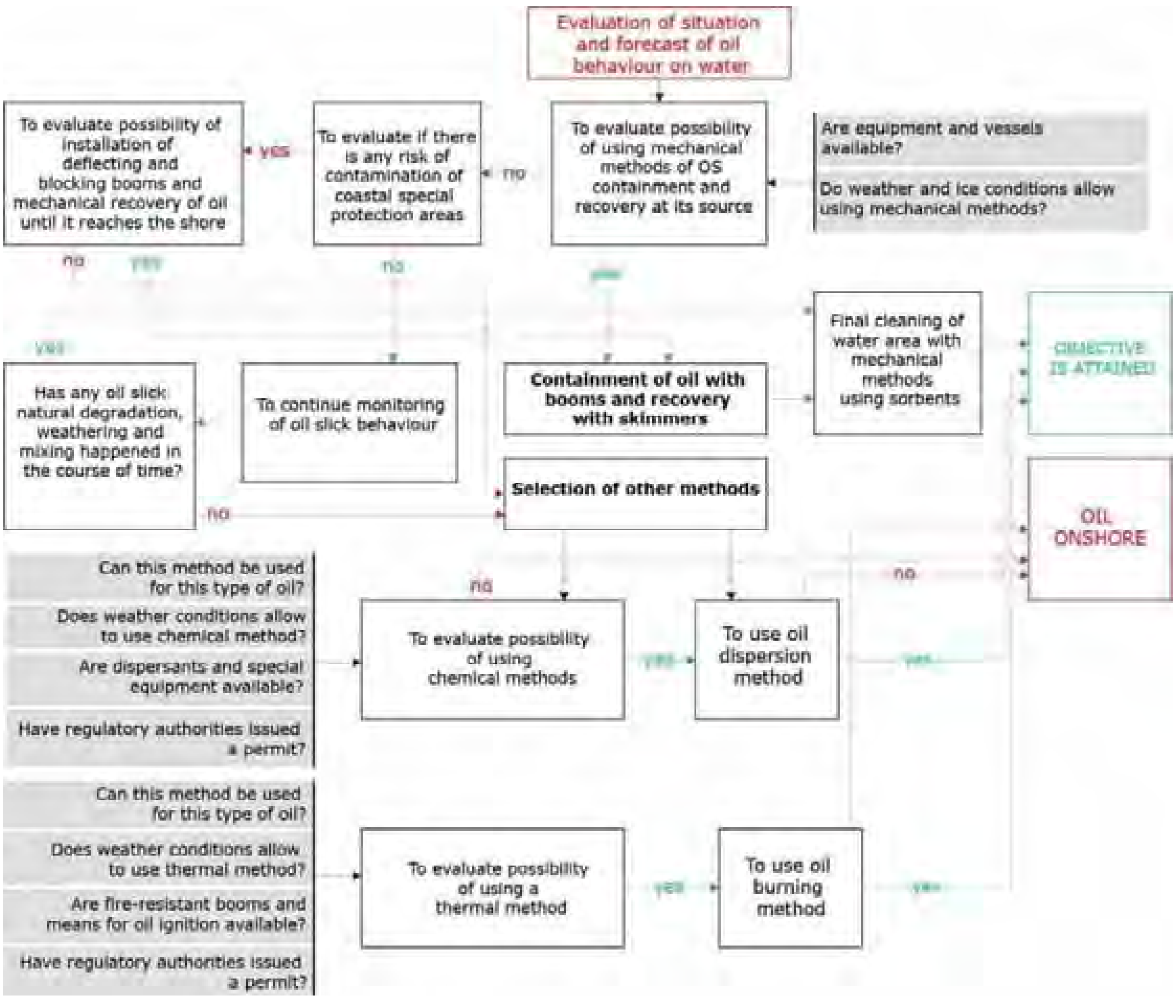


Fig. 6.4. Oil spill response technique decision making algorithm

6.3 Analysis of the Existing Procedures for International Involvement in Case of a Transboundary Oil Spill

6.3.1 Legal Framework for International Involvement in Case of a Transboundary Oil Spill

A transboundary emergency is an emergency which either extends beyond the RF borders or the emergency originates abroad and affects the territory of the Russian Federation (RF Government Resolution No. 1094 of 13.09.1996). In accordance with the Russian legislation response to transboundary emergencies is effected by decision of the RF Government in accordance with international agreements (RF Government resolution No. 794 of 30.12.2003). The interaction with appropriate foreign emergency agencies in case of an oil spill response is effected in accordance with Russia's bilateral and multilateral agreements on cooperation in marine oil pollution control and joint action plans developed under such agreements (Order of the Ministry of Transport No. 53 of 06.04.09). The Ministry of Transport is responsible for implementation of measures connected with meeting Russia's commitments under international agreements on marine oil spill response.

Each individual international agreement sets forth specific procedures for involvement of international facilities and resources in case of a transboundary level oil spill. All international oil spill response cooperation agreements stipulate development of joint response plans. All actions taken by parties to international agreements in accordance with joint response plans shall not breach national regulations and procedures of each Party.

Main provisions of bilateral and multilateral treaties (agreements) on oil spill response cooperation in the Arctic and Barents Euroarctic region signed by the Russian Federation are discussed in Para 2.5.1 of Chapter II.

6.3.2 Procedure for Involvement of International Facilities and Resources

Joint contingency plan

Mutual assistance in responding to oil pollution incidents which can affect the areas of responsibility of parties of bilateral and multilateral treaties (further the Parties) is based on joint oil spill response plans developed and invoked by competent national authorities of the Parties.

The Joint Norwegian-Russian Plan for the Combatment of Oil Pollution in the Barents Sea (further the Joint Contingency Plan) has been used for the analysis of the existing procedures for involvement of international facilities and resources in a transboundary oil spill. The Joint Contingency Plan contains main provisions and up-to-date information on the joint policy of Russia and Norway based on planning, coordination of joint response and communications.

The Joint Contingency Plan may be invoked in the following instances:

- when the Parties ask for assistance in the event of an oil pollution incident which originated within the area of responsibility of one Party and which is accompanied by a threat of oil spreading into the area of responsibility of the other Party, or where such spreading has already occurred;

– in the event of a pollution incident where no oil has spread or threatened to spread into both areas of responsibility but where the magnitude of the incident, or other factors, makes a joint response desirable.
– in the event of an oil pollution incident originating outside the areas of responsibility of both Parties, results in a threat of spreading oil into the area of responsibility of one or both Parties

Mechanism for invoking the Joint Contingency Plan

Parties' joint actions with regard to an oil pollution incident are divided in four phases:

Phase 1 Discovery and Alarm.
Phase 2 Evaluation and Plan Invocation.
Phase 3 Containment, Countermeasures, Cleanup and Disposal.
Phase 4 Documentation and Cost Recovery.

Upon discovery of oil pollution accident at Phase 1 the competent national authority assesses the severity of the incident which is conditioned by the nature and the quantity of the oil and the locality and determines the level of response required and whether or not there is a need to invoke the Joint Contingency Plan. The competent national authorities are the Russian State Maritime Rescue Service of the Russian Maritime and River Transport Agency of the Russian Ministry of Transport in case of Russia and the Norwegian Coastal Administration (NCA) in case of Norway.

The competent national authority who has received information on an oil pollution incident notifies the appropriate Contact points according to the POLREP (pollution reporting)-system [Table 6.2]. The POLREP message shall contain all relevant information on the scale of the incident which constitutes a serious threat to Russia and Norway. The notification is made by telefax and confirmed by telephone.

Table 6.2. Designated contact points under the Joint Norwegian-Russian Plan for the Combatment of Oil Pollution in the Barents Sea

Contact points	Norway	Россия
Primary contact point	Vardø Norwegian Coastal Administration NOR - VTS	Murmansk MRCC
Secondary contact point	Horten Norwegian Coastal Administration Department for Emergency Response	Murmansk Murmansk Salvage Department (MBASU)
		Moscow Ministry of Transport Maritime and River Transport Agency State Maritime Rescue Service

For the purpose of identification POLREP is divided in three parts (Table 6.3). The content of each POLREP part is provided in Table 6.4.

Table 6.3. POLREP system

Part 1 – POLWARN	POLlution WARning	Gives information or warning of pollution or threat of pollution.
Part 2 – POLINF	POLlution and INFormation	Gives detailed supplementary

		information.
Part 3 - POLFAC	POLlution and FACilities	Request for assistance

Table 6.4. Contents of the POLREP parts

Part	Contents
POLWARN	Date and time; position; incident; outflow; acknowledge
POLINF	Date and time; position; characteristics of pollution; source and cause of pollution; wind direction and speed; current or tide; sea state and visibility; drift of pollution; forecast; identity of observer and ships on scene; action taken; photographs or samples; names of other states informed; acknowledge
POLFAC	Date and time; request for assistance; cost; pre-arrangement for the delivery; assistance to where and how; other states requested; change of command; exchange for information; acknowledge

At Phase 2 the contact point receiving the first POLWARN evaluates the situation and if the evaluation is that the oil pollution incident will possibly affect the other Party, the contact centre shall:

- Notify the designated contact point of the other Party;
- In the POLREP- message the Party asks the other Party to invoke the Plan;
- Formulate plans to deal with the incident;
- Initiate Phase 3 and 4 actions as appropriate.

Upon invocation of the Joint Contingency Plan both countries determine the number of units and the amount of equipment that could be placed at the disposal of the lead country and determine how the combatment operation should be continued.

"Lead country"

The Competent authority calling for assistance shall be in charge of the joint operations (lead country). But if the main body of the pollution passes the borderline of a neighbouring country zone the lead country normally transfers the operational command to the other country whose zone is affected by the main body of the pollution. The timing of the shift of operational command should be negotiated between the two countries with regard to the overall picture of the incident and any possible trends in its development.

The lead country shall*:*

- give administrative, operational and logistic support to assisting foreign units,
- give clearly defined tasks to all units,
- organize the practical co-operation between units from the other country,
- keep all units well-informed of the overall situation, and,
- keep firm contact with the command organisations of the assisting country in order to secure that assisting foreign units can be transferred to national command if so necessitated.

Command of the joint combatment operation

The execution of the tasks given to operationally self-supported foreign units must be carried out under the command of the appropriate National on-scene commander/coordinator (NOSC) who must be in close radio contact with the Supreme on-scene commander/coordinator SOSC from the lead country. If the assistance is rendered in the form of equipment or units not operationally self-supported, it is the responsibility of the lead country's operational control or SOSC to integrate the equipment or units in the combatment operation. The main organizational principles of combatment operation control are shown in the diagram. (Fig. 6.4).

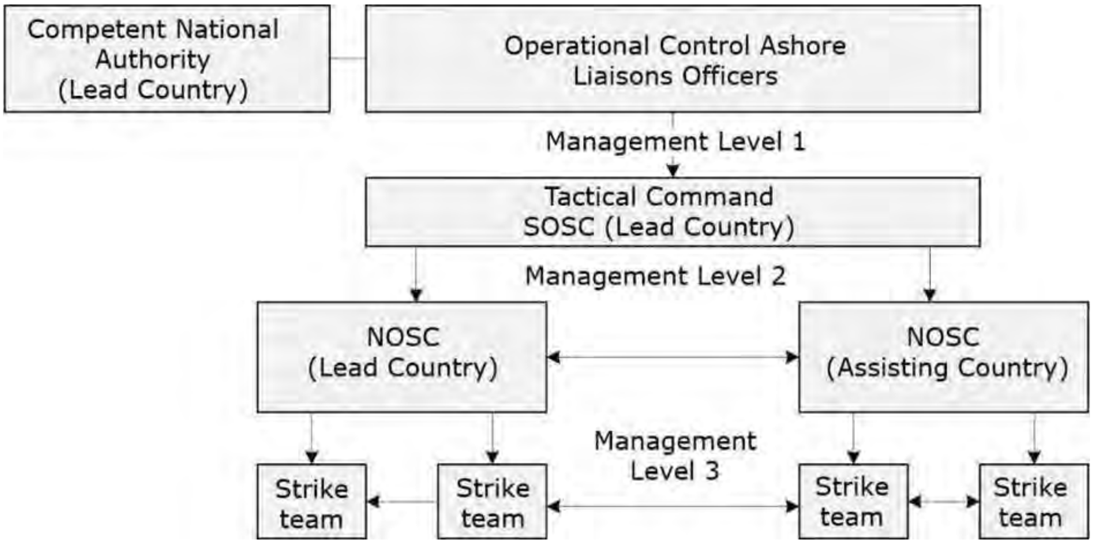


Fig 6.4. Main principles of the command structure for joint oil pollution response operations

Resources for joint operations

The Norwegian Coastal Administration and the competent authorities in Russia make available any resources they may have which could be used for joint response operations, subject to the availability of those resources. In accordance with the plan, during an incident the Joint Response Centre (JRC) is established in the designated facilities of the Party providing the OSC and is shifted to the facilities of the other Party if the OSC is shifted to that Party.

The party requesting and providing assistance should themselves notify their appropriate national authorities (Foreign Office and Customs) of expected times of arrival and departure of strike teams and equipment so as to avoid border problems.

The country providing assistance arranges for transportation of equipment to the place specified by the assisted Party, but the assisted Party bears the total costs if so requested by the assisting State. Arrangements for the disposal of recovered oil and waste should be part of the assisted Party's contingency plan.

On August 2, 2010 the Government of the Russian Federation adopted Resolution No. 592 approving "Procedures for passing the state border by foreign vessels, aircraft and other vehicles involved in response to oil pollution incidents as well as crews, cargos, materials and equipment required for response to such incidents and conditions of their stay". The procedures aim to ease Russian border crossing procedures in the event of international assistance when the oil pollution achieves a transboundary level.

6.3.3 Evaluation and Recommendations of Representatives of the Authorities Responsible for the Interaction of Neighbouring States

According to the representatives of the Russian and Norwegian competent national authorities the parties' almost 20 years experience of cooperation in oil pollution combatment has been only positive. Regular exercises in the Barents Sea, annual joint planning group meetings, experience exchange events, training, etc undoubtedly make a significant contribution both to the enhanced level of preparedness to oil pollution of each country and to the increased level of the joint Russian-Norwegian preparedness to respond to transboundary marine oil pollution.

That said, the Norwegian party notes that regular joint exercises of Russia and Norway carried out pursuant to the Agreement mainly focus on responding to marine oil pollution. The experience from real life shows that in the majority of cases the outflow at sea also pollutes the shore. In Norway all marine oil pollution response activities both off and onshore are coordinated by the Norwegian Coastal Administration. According to NSA senior adviser Mr. Ole Kristian Bjerkemo it would be right to conduct marine oil pollution combatment exercises and exercises on shoreline cleanup as one joint exercise. The issue of shoreline cleanup should also be on the agenda of the annual meeting of the Joint Planning Group. Thus the JPG should include representatives of the RF Ministry of Emergency Situations in addition to the representatives of the Ministry of Transport.

6.4 CONCLUSIONS

The process of making the correct and timely decision with regard to the choice of the oil pollution response technique undoubtedly requires a comprehensive evaluation of the efficiency and safety of selected techniques as the wrong or late decision may result in catastrophic consequences in the event of large oil pollution incidents in the Barents and White Seas. The complexity of the decision making process justifies involvement of a large number of experts as well as representative of the Russian ministries and agencies, whose functions also include evaluation of safety of oil pollution response techniques for the staff, public and environment in addition to the oil pollution response.

Based on the analysis undertaken in the previous chapters an algorithm for selection of a marine oil pollution response technique has been developed (Fig. 6.4). According to the survey (Chapters 4 and 5) and reliable sources (Руководство ..., 2002) the most preferred way to respond to an Arctic marine oil pollution from the point of view of minimizing impact on the most sensitive areas is through the use of mechanical oil recovery techniques. Therefore after the evaluation of the situation and forecasting the oil drift it is first and foremost necessary to determine the possibility to use mechanical methods for containment and collection at the source of the oil pollution. However, as shown above (Chapters 1 and 4) the use of these methods may be complicated by the lack of specialized equipment, for example capable of operating in ice conditions, or by the remoteness of the oil pollution area from oil pollution response bases. Therefore the algorithm includes alternative response methods such as combustion and use of dispersants which could be applied provided a number of requirements are met (Fig. 6.4).

Considering the specific character of oil pollution response in the Barents and White seas and proximity of sensitive areas to main shipping lanes, the said algorithm may be significantly optimized, if recommendations and criteria for evaluation and response method selection are developed for each step of the algorithm, especially given that goals and strategies and subsequently techniques may be changed in the course of the combatment operation under the influence of various factors. Also, taking into account the fact that large oil pollution incidents in the Barents Sea may become transboundary, one can recommend to develop uniform international recommendations and criteria for selection of combatment methods for the Barents Euro/Arctic region. Such recommendations and criteria should be developed in cooperation of relevant ministries and agencies and experts, both nationally and internationally.

7 IMPROVEMENT OF THE EMERGENCY OIL SPILL RESPONSE SYSTEM UNDER THE ARCTIC CONDITIONS FOR PROTECTION OF SENSITIVE COASTAL AREAS (CASE STUDY: THE BARENTS AND THE WHITE SEAS). DRAFT RECOMMENDATIONS

Noting the increasing shipping of oil in the Russian Arctic and the development of new transcontinental shipping routes and thus the increasing risk of emergency oil spills,

Recalling the lessons of large oil spills, including the recent catastrophe in the Gulf of Mexico,

Understanding the need to ensure an adequate level of preparedness for oil spills in the Arctic when the above processes are gaining

OOO Ramboll Barents together with OOO Industrial Safety Systems, Murmansk Marine Biological Institute and the Training and Simulation Centre of the Makarov State Marine Academy, international oil spill preparedness and response consultancy Neocos Consulting and in consultation with the Murmansk Port Administration, Murmansk Salvage Department and the Norwegian Coastal Administration has conducted a study to determine the priority areas and measures to improve the Russian national Arctic oil spill response system using the Barents and White seas as a case study within the framework of a pilot project "Improvement of the emergency oil spill response system under the Arctic conditions for protection of sensitive coastal areas (case study: the Barents and the White seas)".

To have a clear understanding of what elements of the response system need to be reformed first, the pilot project evaluated the existing status of oil transportation in the Russian Arctic, including the analysis of main shipping routes and identification of the most hazardous areas, determination of the main types of transported oil, forecast of likely volumes and consequences of oil spills. The project also looked at the national oil spill response system and its individual elements to see whether the system is sufficient to ensure the required level of preparedness for possible oil spills in the Arctic.

The pilot project reviewed the organization of the Russian marine oil spill response system which is based on three elements. These elements have been carefully studied and analyzed, specifically:

1. Legal framework regulating the operation of the response system and the interaction of its elements.
2. Scientific and methodological support, including the proven technologies and recommendations for the forecasting and prevention of pollution and the conduct of oil spill response operations.
3. Resource base, including the range of resources required to address the practical tasks of prevention and response to oil spills (onshore and offshore infrastructure, specialized facilities and equipment, communications, skills, management, equipment operators, personnel, financial capacities, insurance system, information resources, data acquisition and transmission system, etc).

For an objective assessment the project also studied and took into account the opinions of oil spill experts and specialists in allied fields and proceedings of oil spill response seminars and conferences discussing important problems of Russia's oil spill response system, such as:

Oil spill response: emergency planning, preparedness and response. Regulatory requirements and response workshop. St.Petersburg, 2010;
International Conference on Emergency Prevention and Response in the Arctic, Anadyr, 2009;
Materials of the Arctic Council's Emergency Prevention, Preparedness and Response Working Group;
Materials of the 2000-2010 annual meetings of the joint planning group of the Russian-Norwegian agreement on the Combatment of Oil Pollution in the Barents Sea;
Presentation of the Joint industry program on Oil in Ice, SINTEF, 2010, Tromso, Norway.

The work has resulted in a number of conclusions which have been used as a basis for the development of proposals and recommendations compiled in the present document "Draft recommendations for the improvement of emergency oil spill response system under the Arctic conditions for protection of sensitive coastal areas. (Case study: the Barents and the White Seas".

7.1 Main Objectives of the Pilot Project

7.1.1 Analysis of the Russian and International Experience of Offshore Oil Spill Response under near Arctic Conditions. Assessment of the Efficiency of the Legal Framework of Arctic Countries' Cooperation in Oil Spill Prevention and Response

The analysis of the Russian and international experience of oil spill response under near Arctic conditions has covered the following topics:

– International and Russian experience of offshore oil spill response in the Arctic;
– Lessons learned from oil spill response in the Arctic;
– Russian and international oil spill response methods;
– Cooperation of the Barents countries in oil spill prevention and response;
– Activities and results of the Arctic Council and its working groups;
– Arctic countries' cooperation in improvement of the oil spill response technologies.

The analysis shows that in the wake of large oil spills with major and sometimes catastrophic consequences the international society and governments see the need to revise and improve national oil spill response systems and they are beginning to take steps to toughen up international environmental regulations and requirements. However, the existing international and national maritime environmental requirements and safety regulations are currently unable to ensure nonoccurrence of emergencies which can result in offshore oil spills in the Arctic.

Lessons learned from offshore oil spills indicate that the containment of oil at the source of the spill and prevention of oil contamination of the shore must be the key response approach in order to minimize the damage to the environment and the economy of the affected region.

Russia and other countries have common oil spill response approaches and methods but the selection of an oil spill response technique may depend on the national regulations and standards. Nevertheless, all Arctic countries are facing difficulties with using standard oil spill response technologies in the Arctic and there is a need to find new response methods which would be efficient in the harsh environment, in particular in the ice conditions.

Large oil spills during the last decade have demonstrated the importance of international cooperation and joint efforts of partner-countries in responding to large and transboundary oil spills. The Arctic countries' cooperation in oil spill prevention and response is mainly based on bilateral and multilateral cooperation agreements and memorandums of understanding. However, simple application of the existing procedure for mobilization of facilities and resources is currently insufficient for an efficient oil spill response. It is necessary to continuously enhance the level of preparedness for emergencies through further development and adaptation of existing interaction systems to present day conditions. In that respect regular international events connected with the planning and exercising joint actions, international practical oil spill response exercises, testing of new equipment and sharing experience become especially important.

One of the most important areas is development and improvement of the Arctic oil spill response technologies, especially for ice conditions. According to experts in-situ burning of oil and use of dispersants seem to be the most efficient oil spill response methods in remote areas and in difficult ice conditions, when it is practically impossible to use mechanical equipment. The use of dispersants and burning of oil in Russia are limited by pollution control regulations. Nevertheless, it is important to study the applicability of these methods in the Russian Arctic and possible use of them by the Russian oil spill response agencies taking into account the environment of the coastal areas.

The analysis of the legal framework of the Arctic countries' international cooperation in oil spill prevention and response and study of experts' opinion reveal absence of special strict international regulations in respect of the use and protection of the Arctic resources. All special international instruments pertaining to the Arctic fall into the category of the so-called "soft law" (recommendations, declarations, etc). The Arctic countries see the need to find joint solutions in the following areas:

- Mutual harmonization/synchronization of regulatory framework;
- Development of crisis forecasting and simulation methods, including those for crisis situations resulting from natural disasters;
- Coordination of management decisions;
- Unification of oil spill classifications;
- Unification of risk management principles;
- Development of training programs and training of oil spill response skills.

Enhancement of the regulatory and legal framework for oil spill prevention and response should become one of the first and foremost tasks of the Russian Federation. That said the legal regulation should focus on long-term effects and harmonization of administrative/management decisions with other, first of all Arctic, countries.

7.1.2 Analysis of the Current Oil Spill Response System in the Arctic Zone of the Russian Federation

The pilot project analyzed the organizational structure of the unified state emergency response system and its functional oil spill response subsystem, as the well as the legal framework of the national oil spill response system. The project also looked at the role and functions of commercial emergency rescue entities in the national oil spill response system. Opinions of Russian oil spill response specialists and experts have been used to assess the efficiency of the Russian national oil spill response system.

The following results have been achieved:

- The Russian Federation does not have especial national statutory requirements to the protection of Arctic resources, thus there is no legislative framework to ensure the environmental safety of oil transportation in the Russian Arctic.

- The planning, organization and coordination of oil spill response in Russia falls under jurisdiction of several agencies despite presence of the competent national authority (Russian Maritime and River Transport Agency) responsible for oil spill preparedness and response, which results in duplication of certain powers and lack of clear-cut division of responsibilities.

- Statutory requirements to oil spill response planning, which is based on development of local (facility/site) oil spill contingency plans, are unclear and inconsistent, which allows regulators to take a subjective approach to evaluation of plans for compliance and creates a favourable environment for corruption when getting concurrence and approval of the plans.

- The Russian oil spill response legislation does not take into account commercial emergency response entities which have to finance themselves and operate on a competitive market. Provisions of Federal Law No. 151 mainly focus on government-owned or contingency emergency response entities operating with full or partial support of the government or the parent company.

- The Russian legislation does not provide a clear mechanism for the integration of resources of commercial emergency response entities and organizations into the national response system. Neither does it provide a system for fast reimbursement of their costs for participation in oil spill response operations, which makes it impossible to include resources of commercial emergency response entities in planning of oil spill response on the regional and federal levels.

- The Russian legislation does not provide for a division of functions and responsibilities of government-owned and commercial oil spill response entities thus creating competition between them and undermining the principle of level response and interaction within the national response system.

- The Russian legislation does not require mandatory insurance of risks related to the use of marine resources in operations with oil and oil products.

- According to Russian oil spill response experts and specialists, the current Russian legislation fails to fully ensure efficient operation of the national offshore oil spill response system. Therefore, it is impossible to guarantee that the national response system will be able to operate as one coordinated system which may lead to catastrophic consequences.

7.1.3 Mapping of Oil Sensitive Coastal Areas of the Barents and White Seas

The pilot project has developed seasonal maps of ranked distribution of main groups of marine organisms (phytoplankton, zooplankton, ichthyoplankton, benthos, marine mammals and birds) in the Barents and White Seas. The consolidated distribution maps have been developed based on results of biological and ecosystem surveys, monitoring of fish and invertebrate catches, extensive reference data, as well as expert opinions of the specialists of the Murmansk Marine Biological Institute (MMBI) and the Polar Research Institute of Marine Fisheries and Oceanography (PINRO).

Vulnerability indexes have been established taking into account the toxic vulnerability of various groups of marine organisms to oil pollution (consolidation of toxic vulnerability results and expert opinions).

Summary vulnerability maps (compilation of relative vulnerability maps of all components) have been developed with the help of ArcGIS 9.0 software, where a maximum value of the vulnerability index corresponds to the maximum vulnerability of a coastal area.
Resulting maps indicate that the most vulnerable coastal areas of the Barents Sea are the northern coast of the Kola Peninsula and the western coast of the Novaya Zemlya Archipelago. The most vulnerable area of the White Sea is its western coast from the Kandalaksha Bay to the Onega Bay.

The results of mapping have been used to model possible oil spills in the Barents and White Seas.

7.1.4 Characterization of Main Types of Oil and Petroleum Products Shipped in the Barents and White Seas and Determination of their Behaviour under Different Hydrometeorological Conditions

7.1.4.1 Analysis of Main Shipping Routes and Types of Oil Exported via the Barents and the White Seas.

The pilot project has analyzed Russian export oil shipping patterns in the Barents and the White Seas, specified major advantages of the Barents Sea route for the export of Russian oil and identified main flows of the Russian oil converging in the Barents Sea.

A qualitative and quantitative analysis of different types of oil transported in the Barents and the White Seas has been performed with the assistance of the Murmansk Port Administration and major oil shippers. As of October 2010 most common types of shipped oil are high-sulphur and medium-sulphur crude, stable gas condensate, naphtha and M-100 fuel oil. The project has collected data of laboratory tests contained in the quality certificates of oil and oil products shipped in the Barents and the White Seas. The acquired data have been used to simulate the behaviour of different oils on the water surface.

7.1.4.2 Simulation of Oil Behaviour on the Water Surface

Transas PICSES II software has been used to simulate behaviour of different oils in different hydrometeorological conditions in the Barents and White Seas. The input data for the simulation included location of possible oil spills, properties of main types of oil, volume of the spill and hydrometeorological conditions. The simulation of each spill was made for each season taking into account prevailing winds in each season.

For the modeling of scenarios of possible oil spills two areas were chosen, one in each of the seas. The areas are located at the intersection of main oil shipping lanes and in navigation hazardous areas (congested areas). The selected areas of possible incidents are located close to the shores with high vulnerability to oil spills.

32 most representative out of 88 analyzed simulations have been selected. In our opinion, these are of the most interest for further analysis in the pilot project. These are

mainly models of spills where the oil is expected to reach the shore within a short time and spills in ice conditions. The analysis of these scenarios shows that:

– The oil reaches the shoreline within a short time and threatens environmental sensitive coastal areas both in the Barents Sea and the White Sea in the majority of cases and under different hydrometerological conditions.

– The behaviour of different oils on water differs depending on their physical and chemical properties. Naphtha and stable gas condensate are more prone to weathering (evaporation and dispersal) and they are expected to quickly degrade naturally. Acute toxic impact on living organisms in the coastal areas is expected in the initial stages, but the impact will decrease with the weathering. Crude oil and M-100 fuel oil are a lot less prone to weathering and reach the shoreline almost in unchanged condition. In this case the living organisms will be exposed to both toxic and mechanical impact over a long period.

– In case of an oil spill in the White Sea in the winter, the oil will not reach the shore as the ice in the gullet of the White Sea prevents the spread of oil on water. In the spring the contaminated ice will melt and most of it will be washed out from the gullet of the White Sea to the Barents Sea. Oil pollution of the shore is also likely when the drifting ice melts.

7.1.5 Analysis of the Applicability of Existing Oil Spill Response Technologies to Protection of Sensitive Coastal Areas of the Barents and the White Seas Taking into Account the Net Environmental Benefit

An analysis of existing technologies of oil spill response and protection of sensitive coastal areas has been performed to assess their applicability in the Barents and the White Seas, also under the ice conditions in the White Sea. The project has identified the optimal oil spill response technologies based on their efficiency under the Arctic conditions with regard to the types of oil in question considering the oil spill response crew safety and minimization of environmental damage and legal framework for their application. The analysis takes into account results of computer simulations based on the assumption that the main objective of the response is to prevent or minimize possible contamination of the coastal areas and valuable natural objects.

Main offshore oil spill response methods have been reviewed in the course of the analysis, in particular:

1) Mechanical method (oil containment, collection and recovery from the surface);
2) Chemical method (dispersing of oil slick to expedite its dissolution and degradation under the impact of natural factors);
3) Thermal method (in-situ burning of oil).

The following conclusions have been drawn as a result of the analysis:

– The optimal and safest available technique in case of a spill of fuel oil or crude oil in the open waters of the Barents and White Seas will be mechanical containment, collection and recovery and use of mechanical methods for the protection of the shore and especially valuable areas.

– The most acceptable strategy in case of an oil spill under the ice conditions of the White Sea will be to mechanically collect the oil using specialized equipment suitable for ice conditions and ice class oil spill response vessels, monitor the area until spring and take measures to prevent possible pollution of the coast resulting from melting of the oil contaminated ice.

– Notwithstanding the fact that burning of oil is more efficient and least costly in certain conditions in comparison with the mechanical method and that it is the only efficient method in case of broken or drifting ice, the burning of oil cannot be used in practice in the areas in question due to the proximity to the shores and their high environmental sensitivity. The use of burning may be complicated under the ice conditions of the White Sea because the smoke from the burning may damage the Greenland seals on their breeding grounds on the ice. Apart from that the in-situ burning of oil in the Russian seas is limited by regulations.

– Chemical oil spill response methods using permitted dispersants are substantially limited by climatic, hydrometeorological and ice conditions of the Barents and White Seas, thus making them currently inefficient according to the majority of specialists.

– In case of a spill stable gas condensate or naphtha will spread quickly as a thin film on the surface of water. In such a case the containment and collection of oil will be both inefficient and extremely hazardous due to high explosion and fire risk until full evaporation of volatile fractions. In this light it is expected that the most reasonable strategy will be to make no effort to contain and recover the oil as long as there is a risk of explosion or fire. If stable gas condensate or naphtha reach the shore the safest response again will be to make no effort to remove them, especially in areas of high tidal activity, on the rocky shores, where oil is most likely to degrade naturally.

7.1.6 Comparative Analysis of the Required Oil Spill Response Facilities and Resources and Technical Capabilities of the Specialized Emergency Units to Respond to Oil Spills in the Barents and White Seas and to Protect Sensitive Coastal Areas

The pilot project has made a comparative analysis of the required oil spill response facilities and resources and technical capabilities of the specialized emergency units of the Murmansk and Arkhangelsk regions to respond to possible spills resulting from the shipping of oil in the Barents and the White Seas. Since preparedness for large oil spills is a national level issue, the pilot project has analyzed technical capabilities of the specialized government-owned organizations/units tasked with oil spill response. The analysis did not include the facilities and resources of commercial oil spill response entities in the region in the absence of a legal framework for their engagement and reimbursement of their costs.

Thus, the project has reviewed and analyzed technical capabilities of the Murmansk Salvage Department (MBASU) under the Russian Maritime and River Transport Agency of the Ministry of Transport and being a part of a functional oil spill response subsystem within its area of responsibility, as well as technical capabilities of the Northern Branch of Gosakvaspas under the Ministry of Emergency Situations which participates in offshore oil spill response operations.

The comparative analysis of the needs for facilities and resources and technical capabilities of the Murmansk Salvage Department and the Northern Branch of Gosakvaspas to respond to oil spills has been performed taking into account results of the simulations and the main objective of the response which is to prevent or minimize possible pollution of coastal areas and valuable nature objects. The following conclusions have been drawn from the analysis:

- The bulk of the oil spill response facilities and resources of the Murmansk Salvage Department (MBASU) is located in the port of Murmansk in the southern part of the Kola Bay of the Barents Sea at a considerable distance from oil shipping lanes and mainly focuses on oil spill response preparedness at several hazardous facilities (specialized ports and terminals). Two oil spill response vessels of FSUE MBASU with special equipment onboard are always on duty in the Barents Sea area in full preparedness for oil spill response. However, they are not sufficient for timely response to large oil spills to prevent coast contamination with oil. Some of MBASU's equipment is located at its Arkhangelsk branch. The equipment and vessels of the Northern Branch of Gosakvaspas are located at the base in the port of Arkhangelsk in the mouth of the Northern Dvina River also at a considerable distance from main oil transportation routes. There is no provision for intermediary onshore bases for the stationing of oil spill response facilities and resources on the coasts of the Barents and White Seas along the shipping routes.

- MBASU has a sufficient number of skimmers, including large-capacity skimmers, for collection of oil in open water. However, the majority of them is inefficient and in some cases is unusable under the ice conditions. MBASU does not have specialized "Arctic" skimmers to operate in broken ice.

- The total number of booms at MBASU is generally adequate for containment of large oil spills in open water. There are special booms for ice conditions at their base in Arkhangelsk totaling only 50 metres.

- There are not enough specialized oil spill response vessels, including ice-class vessels with unlimited sailing range and considerable endurance, to ensure oil spill preparedness in the Barents and the White Seas.

- The Arkhangelsk Branch of MBASU has only small vessels for summer navigation. The White Sea Branch of MBASU in Kandalaksha has no vessels carrying oil spill response equipment. There is a vessel of the Northern Branch of Gosakvaspas which meets the endurance requirements in the port of Arkhangelsk but it has no specialized oil spill recovery equipment onboard. It will take at least 24 to 36 hours for a specialized oil spill response vessel from the port of Murmansk to reach an oil spill in the White Sea. Thus, the mechanical collection of at least part of the oil in case of a spill under the ice conditions of the White Sea seems impossible.

Therefore, timely response to oil spills along the shipping routes of the Barents and White Seas to prevent coast contamination by oil is hardly possible. The technical capabilities of the government-owned emergency organizations responding to oil spills in the Barents and the White Seas are not adequate to ensure environmental safety of the seas and coastal areas during the shipping of oil along the shipping routes in the Barents and White Seas. Available facilities and equipment of the specialized oil spill response units in the Barents and the Whites Seas badly needs upgrading and expanding.

7.2 Recommendations for Improvement of the Oil Spill Response System under the Arctic Conditions for Protection of Sensitive Coastal Areas

Based on the conclusions drawn in the course of the pilot project a number of proposals and recommendations have been developed which may be useful in developing measures to enhance the Russian national oil spill response system and ensure the required level of preparedness to respond to possible oil spills in the Arctic.

The proposals and recommendations have been broken down into chapters in accordance with the response system's organizational structure assumed in the pilot project.

7.2.1 Proposals and Recommendations for Improvement of Legal Framework for the Operation of the Oil Spill Response System in the Arctic:

7.2.1.1. To speed up preparation and adoption of the Federal Law "On protection of Seas of the Russian Federation from Oil Contamination" as a most efficient tool for modernization of the national system of preparedness for oil spill response. The Law introduces measures of direct economic regulation of all aspects of activities in protection of seas from catastrophic events causing harm to environment. Namely, the measures as as follows:

- compulsory environmental insurance of relative risks;
- establishment of a special fund to cover expenses related to provision of preparedness for oil spill response, development of a mechanism for its formation and procedure for financing environmental measures.

To recommend the Federal Assembly of the Russian Federation to consider the draft Federal Law "On protection of Seas of the Russian Federation from Oil Contamination" a top priority, subject to urgent review by the State Duma.

7.2.1.2. To regulate at a legislative level aspects of planning, organization and coordination of oil spill response measures, namely:

- to amend the regulations on the unified system RS ES, specifying used terms and definitions and defining how the system is supported at each level;
- to eliminate duplication of authority of ministries and departments in control of oil spill response preparedness;
- to regulate authority and responsibility for organization and implementation of coast clean-up activities in cases when contamination is a consequence of offshore oil spill;
- to establish an edifice of authorities with clear delimitation of competence and sufficient financial provision of efficient activities;
- to revise the existing system of OSR planning at all levels;
- to revise norms of oil spill containment timeframes based on world practice;
- to agree provisions of main legislative and regulatory documents stipulating OSR actions and to provide consistency of these provisions;

7.2.1.3. To provide a legal framework for integration of resources of commercial ASF(n) and organizations of Russian oil and gas industry into a national system of oil spill response of the regional and federal levels, namely:

- To introduce a provision into the relative legislative documents on an obligation of professional commercial ASF(n) and non-professional ASF(n) of organizations of oil and gas industry to provide support and assistance to state organizations in oil spill response. This assistance may be in a form of providing special OSR equipment or performing specific works on OSR by ASF(n) personnel;

- To provide a legal basis for a system of prompt compensation of expenses of professional commercial ASF(n) and non-professional ASF(n) of organizations of oil and gas industry for OSR operations. To define persons responsible for provision of compensation for ASF(n) expenses for OSR operations.

7.2.1.4. For the purpose of providing adequate level of preparedness for oil spill response during offshore operation of oil and gas facilities and also of strengthening the state's role in OSR in practice, to establish a legal basis for a system of distribution of functions and responsibility between state organizations responsible for OSR and professional commercial ASF(n) depending on the level of possible oil spill at such facilities, namely:

– To establish by law a priority of state organizations responsible for OSR, namely FSI Gosmorspassluzhba of Russia and its regional units, in providing preparedness for OSR at oil and gas facilities, where possible oil spills are of regional and federal OSR levels according to the offshore oil spill classification, established by the RF legislation;

– To establish by law a right of professional commercial units to render services in oil spill prevention and response at oil and gas facilities, where possible oil spills do not exceed the volumes of local OSR level according to the offshore oil spill classification, established by the RF legislation;

– To oblige by law oil and gas facilities to have commercial agreements for provision of preparedness for OSR in accordance with proposed distribution of functions between state and commercial professional organizations.

7.2.1.5. To provide a legal basis for establishing and operation of voluntary teams for protection of coastal line and response to coast contamination by oil, namely:

– To consider a possibility for state financing of regular training programmes for volunteers in clean-up of shore contaminated with oil as a result of offshore oil spill;

– To develop a mechanism for material support to volunteers from the state;

– To develop a mechanism for involving trained volunteers in OSR;

– To develop regulations for involving volunteers based on safety rules during OSR and a procedure for remuneration of volunteers involvement.

7.2.1.6. To consider a possibility to change shipping routes used for transportation of hydrocarbons along the Russian Arctic coast. This will allow to considerably reduce a risk of shore oil contamination caused by oil spills from tankers, and will give more time to emergency units for OSR. For example, starting from 01 July 2007 Norway has moved the shipping routes for transit vessels going through the Norwegian economic zone 50 miles northwards of its coast.

7.2.2 Proposals and Recommendations to Improve the Scientific and Methodological Support of the Arctic Oil Spill Response System:

7.2.2.1. To assess the risk of emergency oil spills on the shipping lanes of the Arctic seas, identify coastal areas with the highest risk of oil pollution, assess potential environmental damage, identify optimal response strategy in case of a pollution hazard to these areas.

7.2.2.2. To develop a state programme of development of new OSR technologies efficient for the Arctic conditions. An example of such programme is the Norwegian Technology Development Programme «Oljevern 2010», based on selection of best national projects and ideas on a competitive basis for further financing by the state.

7.2.2.3. To develop a long-term comprehensive programme of weathering studies of physical and chemical properties of oil transported in the Russian Arctic Seas when spilt on sea water, as well as of testing modern chemical dispersants for oil spill response under Arctic conditions. The Programme shall include laboratory and field studies, as well as studies of impact of dispersants on marine bioresources.

For these studies we recommend using a specialized laboratory established for this very purpose in the Murmansk region in 2008 by the Government of the Murmansk region and the Norwegian company Statoil under the frames of the Memorandum of Understanding on Technical and Economic Cooperation. The result of the programme implementation shall be establishment of a database of oils and up-to-date chemical dispersants efficient under Arctic conditions. Availability of such database will allow in case of oil spills to make express analyses of physical and chemical properties of spilt oil, simulate oil behaviour on sea water and provide prompt forecast of possible consequences of oil spill. The obtained data will give a possibility to emergency and rescue services responsible for OSR, to make optimal and timely decision on selection of an OSR technology, and, hence, considerable mitigate or prevent unfavourable impact of oil spill on environment.

7.2.2.4. To summarize existing Russian and western approaches to estimate the need for forces and oil spill containment and recovery equipment. To summarize experience gained during exercise and real OSR operations in cold seas.

7.2.2.5. Based on the collected materials, to develop and agree with interested federal authorities a separate methodology of estimate of the need for forces and means for oil spill containment and recovery in the Arctic, including those for ice conditions.

7.2.2.6. Due to the considerable increase in shipping and handling of gas condensate in the Arctic seas and the special response-limiting hazard of this substance, there is a need to develop a comprehensive programme to study gas condensate spill response under the Arctic conditions which would include the following actions:

– assessment of risk to the population and the environment from the handling of gas condensate in main Arctic ports and terminals;
– detailed study of gas condensate behaviour on water surface;
– development of safe response strategies;
– special training programs for OSR strike teams;
– recommendations for the additional equipment and personal protective equipment for the strike teams responding to gas condensate spills.

7.2.2.7. To develop a unified method for development of oil pollution sensitivity maps of the coast for Russia subject to the shore structure and marine organisms' vulnerability to different oils on the basis of generalization of the existing Russian and western approaches.

To apply new unified methodology for the development of vulnerability atlas for the coasts and offshore strip of the Arctic seas of the Russian Federation.

To deliver copies of the atlas to the appropriate salvage departments and salvage, ship-lifting and subsea operations departments, marine terminal administrations and other state bodies concerned for strategic and tactic planning in case of oil spill response.

7.2.2.8. To recommend the appropriate executive bodies, including state nature protection agencies, to utilize new technology for sea water cleansing from the oil film by installation of biofilter plantation based on the symbiotic association of algae and hydrocarbon oxidizing bacteria in the areas of permanent pollution sources of the offshore strip.

The technology capabilities were successfully demonstrated during the implementation of the pilot project 'Cleansing of Arctic sea water' by the team of specialists experienced in marine biology, biotechnology, hydrology, engineering and environment united at OOO SIRENA within the implementation of the project 'Russian Federation – Support to the National Action Plan for Protection of the Arctic Marine Environment' under the auspices of the enterprise 'Administrative Directorate of the Russian Investment Programme for the Environment Enhancement'.

7.2.2.9. To develop and effect a regional plan for the rehabilitation of sea birds and marine mammals affected by oil pollution taking into account the Arctic environment containing the following main conditions:

- criteria of the necessity and methods of providing assistance to birds and mammals in accordance with international standards;
- participants and a coordinating body for rehabilitation of marine birds and mammals;
- required facilities and resources for rehabilitation of marine birds and mammals and procedures of their rapid mobilization;
- evaluation of the need to engage experts and volunteers from neighbouring countries;
- evaluation of the possibility to apply for international funding for the required activities.

7.2.3 Proposals and Recommendations for Improvement of the Arctic Oil Spill Response Resources:

7.2.3.1 To provide the government oil spill response organizations with the required number of specialized and support vessels for oil spill response operations, including ice class vessels and specialized equipment for ice conditions.

To apply to Rosmorrechflot (Federal Marine and River Transport Agency) with a request to transfer an enhanced ice class salvage vessel of MPSV 07 4 Mw design to FSUE MBASU in 2011.

7.2.3.2. To recommend Rosmorrechflot of Russia and FSI Gosmorspassluzhba of Russia to provide for possibility of agreement with the icebreaking fleet to utilize ice breakers as carriers of OSR equipment with the OSR crew during winter time.

7.2.3.3. To create onshore OSR bases in sea ports with administrations (marine terminal administration) as well as intermediate base stations of OSR facilities and resources near the routes of tankers along the coastal line of the Russian Arctic area for the purpose of prompt response to oil spills at navigational routes in the Arctic water areas.

7.2.3.4. To ensure readiness to the timely emergency towing of the damaged vessels, failed to sail, in the Russian Arctic area on the governmental level.

7.2.3.5. To provide for organization on the territory of the Murmansk region of the safe temporary storage sites for oily waste generated during oil recovery operations and shore cleansing actions. To develop a scheme of further treatment of oily waste taking into account the lack of modern facilities for high-level processing of oily waste in the region up to date. These measures are necessary for the construction and commissioning of the projected complex for decontamination, utilization and storage of oily waste in the Murmansk region.

7.2.3.6. To develop a programme of involvement of local population of coastal areas of the Barents and White seas into the voluntary teams aimed at training of inhabitants in participation in the shoreline protection and cleansing in case of oil spills in Arctic waters.

8 PROPOSALS FOR POSSIBILITIES TO IMPLEMENT INVESTMENT PROJECT IN RESPONSE TO ACCIDENTAL OIL AND PETROLEUM PRODUCTS SPILLS UNDER ARCTIC CONDITIONS

The project "Study of Possibilities to Establish Intermediate Base for OSR Forces and Resources on the Coast of the Kola Peninsula to Provide Timely Oil Spill Response" proposed for consideration is not an investment project in its traditional meaning, since it does not provide for financial income. However, as agreed with the Customer, and taking into account that intermediate bases for OSP forces and resources in the areas far away from main basin salvage facilities are of great importance, the project is considered as a part of the complex solution of the problem of oil and petroleum product spill response in the Artic region and mitigation of negative impact of the Artic marine and natural environment.

The analysis of the Russian oil spill response system in the Artic described in Chapters 1-7 of the Project Report "Improvement of the Emergency Oil Spill Response System under the Arctic Conditions for Protection of Sensitive Coastal Areas (Case Study: the Barents and the White Seas)" has shown that one of the obstacles for efficient emergency offshore oil spill response is large distance between the OSR forces and resources of FSUE MBASU and the navigation routes used for oil transportation in the Barents and the White Seas. Finding solution to this issue is a top-priority action because even if FSUE MBASU is fully equipped, large distance between the OSR means and possible sites of their application makes these means low-efficient if the oil spill occurs far away from the FSUE MBASU facilities. Based on the aforesaid and to provide timely response to oil spills, there is a need for intermediate bases for OSR forces and resources on the coasts of the Barents and White Seas along the navigation routes. However, lack of experience in establishing and operating such bases in Russia makes development and implementation of this concept difficult. Taking into account that implementation of proposed actions is a complex and capital-intensive process, we propose to start with a study to evaluate possibilities of establishing such bases. This will allow fully assessing legal, financial, economic, technical, process, human resources and other aspects of establishing and operating intermediate OSR forces and resources bases. Moreover, implementation of the project will give a possibility to evaluate feasibility of involving local population of coastal settlements in activities of such bases. If a positive decision on establishing such bases is taken, the study results will allow optimizing the process of their organization, avoiding mistakes and unjustified cost.

8.1 Project Scope

The pilot project "Study of Possibilities to Establish Intermediate Base for OSR Forces and Resources on the Coast of the Kola Peninsula to Provide Timely Oil Spill Response" includes a number of interdependent tasks aimed at full study of possibilities to establish high-efficient unit of FSUE MBASU in a remote area on the coast of the Kola Peninsula.
The objective of the Project is to carry out a full-scale study allowing to make more comprehensive and objective evaluation of possibilities to establish an intermediate OSR forces and resources base in a remote coastal area of the Kola Peninsula.
Sequence and scope of tasks:

1. **Analysis of existing legislative and regulatory framework stipulating establishment and operation of an intermediate OSR forces and resources base.**

This section will cover a full-scale analysis of applicable legislative and regulatory framework to evaluate a possibility and legal frames of establishing an intermediate OSR forces and resources base and to develop possible proposals to improve the existing requirements.

2. Study of procedures to be followed to establish an intermediate OSR forces and resources base. Development of an Action Plan.

The study will result in a comprehensive list of documents required to establish, register and certify an intermediate OSR forces and resources base. It will include estimate of time required for each organizational action, actions sequence, as well as an action plan to establish a base.

3. Selection of a site for a planned intermediate OSR forces and resources base on the coast of the Kola Peninsula.

Based on the data on current and planned future oil sea transportation, the results of previous studies, including the ones described in Chapters 1-7 of this Report and in agreement with the organizations responsible for emergency and rescue actions and oil spill response, this study will cover identification of the following:

A) An area on the Kola Peninsula, meeting the following requirements:

- maximum proximity to one or a number of special sensitive areas;
- considerable distance from main OSR forces and resources bases;
- maximum proximity to shipping routes in the Barents and White Seas used for transportation of oil and petroleum products;
- availability of a coastal settlement with a reserve of unemployed capable to work population and required infrastructure (communication systems, power supply).

B) Location of an intermediate OSR forces and resources base;

C) Borders of the area of responsibility of an intermediate OSR forces and resources base.

4. Detailed study of the site for an intermediate OSR forces and resources base. Study of local population opinion on their participation in voluntary salvage teams for oil spill response.

The following shall be done for this purpose:

- To make a list of all settlements in the selected area with temporary or permanent population;
- To collect data on size and structure of capable to work population, to find out willingness and degree of population participation in activities of irregular salvage teams on a voluntary basis;
- To collect, summarize and analyze data on the number and technical capabilities of floating craft owned by organizations and private persons in the area of a proposed site for an intermediate OSR forces and resources base. Study of opinion of owners of these floating craft on possible participation in oil spill response operations;

- To develop a list and scope of main types of assistance that state-owned emergency and rescue units would like to receive from population of a coastal settlement;

- To develop maps of all existing transport facilities and routes in the area of location of an intermediate OSR forces and resources base, including water, air, seasonal routes and local vehicular roads;

- To develop a detailed description of shoreline, climate, tidal and other peculiarities of the area of location of an intermediate OSR forces and resources base.

5. Estimate of the potential and technical capabilities of an intermediate OSR forces and resources base taking into account capabilities of voluntary salvage teams of local population. Development of proposals for organizational and personnel structure and procedures to involve permanent and outsourced personnel of the base.

Taking into account the data obtained during the study of the site of an intermediate OSR forces and resources base, it will be required to prepare an estimate of a number of required personnel and technical equipment and facilities, allowing for containment of emergency oil spills until the personnel from the main OSR force and resources bases arrives. The prepared estimates will be used as a basis for developing the organizational and personnel structure of an intermediate OSR forces and resources base taking into account possibilities to involve outsourced personnel out of local population.

6. Preparation of proposals for an operating procedure for an intermediate OSR forces and resources base in case of an accidental oil spill taking into account involvement of voluntary salvage teams. Development of the system of interaction between an intermediate OSR forces and resources base and other emergency and rescue units.

The proposal for an operating procedure for an intermediate OSR forces and resources base in case of accidental oil spills shall be developed taking into account assessment of preparedness of local population and organizations located in the area of the base operation for assisting the permanent emergency and rescue units. The proposal shall be prepared considering the base technical level, procedures of the existing system of OSR and interaction with all emergency and rescue units. The proposed system of interaction shall be agreed with other emergency and rescue units.

7. The cost estimate for implementation of the project to establish an intermediate OSR forces and resources base.

This task will include accounting of all possible expenses to establish an intermediate OSR forces and resource base, as well as expenses for its subsequent day-to-day operation, and development of the capital and operational cost estimate.

8. Analysis of possible financing sources.

This analysis will cover study of possible financing sources (local, regional, federal and off-budget) and other options of material support for establishing and subsequent operation of an intermediate OSR forces and resource base, including possible international financing sources.

8.2 Project Cost

According to the tentative estimates, the total project cost will be 4 562 000 roubles.

Task No.	Task Description	Day Rate, roubles	Days	Sum
	MAIN WORK			
1	Analysis of existing legislative and regulatory framework stipulating establishment and operation of an intermediate OSR forces and resources base.	18 000	50	900 000
2	Study of procedures to be followed to establish an intermediate OSR forces and resources base. Development of an Action Plan.	18 000	23	414 000
3	Selection of a site for a planned intermediate OSR forces and resources base on the coast of the Kola Peninsula.	18 000	6	108 000
4	Detailed study of the site for an intermediate OSR forces and resources base. Study of local population opinion on their participation in voluntary salvage teams for oil spill response.	18 000	20	360 000
5	Estimate of the potential and technical capabilities of an intermediate OSR forces and resources base taking into account capabilities of voluntary salvage teams of local population. Development of proposals for organizational and personnel structure and procedures to involve permanent and outsourced personnel of the base.	18 000	25	450 000
6	Preparation of proposals for an operating procedure for an intermediate OSR forces and resources base in case of an accidental oil spill taking into account involvement of voluntary salvage teams. Development of the system of interaction between an intermediate OSR forces and resources base and other emergency and rescue units.	18 000	11	198 000
7	The cost estimate for implementation of the project to establish an intermediate OSR forces and resources base.	18 000	23	414 000
8	Analysis of possible financing sources.	18 000	11	198 000
	TOTAL FOR MAIN WORK		**169**	**3 042 000**
	AUXILIARY WORK			
9	Travel:	Expenses/ day (incl. day rate)	Days	Sum
9.1	Travel to a planned site of an intermediate OSR forces and resources base (by helicopter)	250 000	4	1 000 000
9.2	Travel inside Russia for participation in coordination meetings	40 000	4	160 000
10	Translation of documents to/from a foreign language (IF FOREIGN INVESTORS ARE INVOLVED IN THE PROJECT)	18 000	20	360 000
	TOTAL FOR AUXILIARY WORK		**28**	**1 520 000**
	TOTAL FOR THE PROJECT		**197**	**4 562 000**

8.3 Financing Sources

Taking into account that this project is not a commercial one and does not provide for gaining profit, main sources of its financing may be Russian and international environmental funds and programmes. In addition, funding to the project may be provided either by oil and gas companies planning to develop their activities in the region, or by operators of oil and gas transportation via the Barents and White Seas.

8.4 Project Duration

The estimated duration of the project is 6 months.

Task No.	Task Description	Months						
		1	2	3	4	5	6	7
1	Analysis of existing legislative and regulatory framework stipulating establishment and operation of an intermediate OSR forces and resources base.							
2	Study of procedures to be followed to establish an intermediate OSR forces and resources base. Development of an Action Plan.							
3	Selection of a site for a planned intermediate OSR forces and resources base on the coast of the Kola Peninsula.							
4	Detailed study of the site for an intermediate OSR forces and resources base. Study of local population opinion on their participation in voluntary salvage teams for oil spill response.							
5	Estimate of the potential and technical capabilities of an intermediate OSR forces and resources base taking into account capabilities of voluntary salvage teams of local population. Development of proposals for organizational and personnel structure and procedures to involve permanent and outsourced personnel of the base.							
6	Preparation of proposals for an operating procedure for an intermediate OSR forces and resources base in case of an accidental oil spill taking into account involvement of voluntary salvage teams. Development of the system of interaction between an intermediate OSR forces and resources base and other emergency and rescue units.							
7	The cost estimate for implementation of the project to establish an intermediate OSR forces and resources base.							
8	Analysis of possible financing sources.							

8.5 Expected Project Outcome

The main outcome of the project will be a conclusion on a possibility of establishing such bases on the coast of the Kola Peninsula along the main navigation routes. Implementation of this project will give a possibility to get an overview of required technical, financial and other resources for establishment of a typical intermediate OSR forces and resources base. This will also allow identifying administrative and legal issues that need to be solved to establish such a base. Moreover, the study on social environment and willingness of population to be involved in contingency oil spill response operations will allow evaluating a possibility to include participation of local inhabitants in plans of FSUE MBASU and thus to rationalize expenses.

9 BRIEF REPORT ON THE WORKSHOP BASED ON THE RESULTS OF THE PILOT PROJECT AND SHARE OF GAINED EXPERIENCE AMONG INTERESTED ORGANIZATIONS

On completion of Tasks 1-8 and Draft Recommendations on Improvement of the Emergency Oil Spill Response System under the Arctic Conditions for Protection of Sensitive Coastal Areas (Case Study: the Barents and the White Seas) there was a workshop arranged on the 2nd of November 2010 in Murmansk with participation of the parties involved in this issue in the Barents Sea.

The experience gained during implementation of the Pilot Project and the Draft Recommendations were shared with interested parties. The received comments and proposals of experts in OSR for including additional recommendations were considered and taken into account in preparation of Draft Recommendations (Chapter 7). Summary of the meeting with the comments and recommendations of the interested organizations, meeting agenda, list of participants as well as the presentation materials of the Pilot Project results are presented in Appendix E.

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