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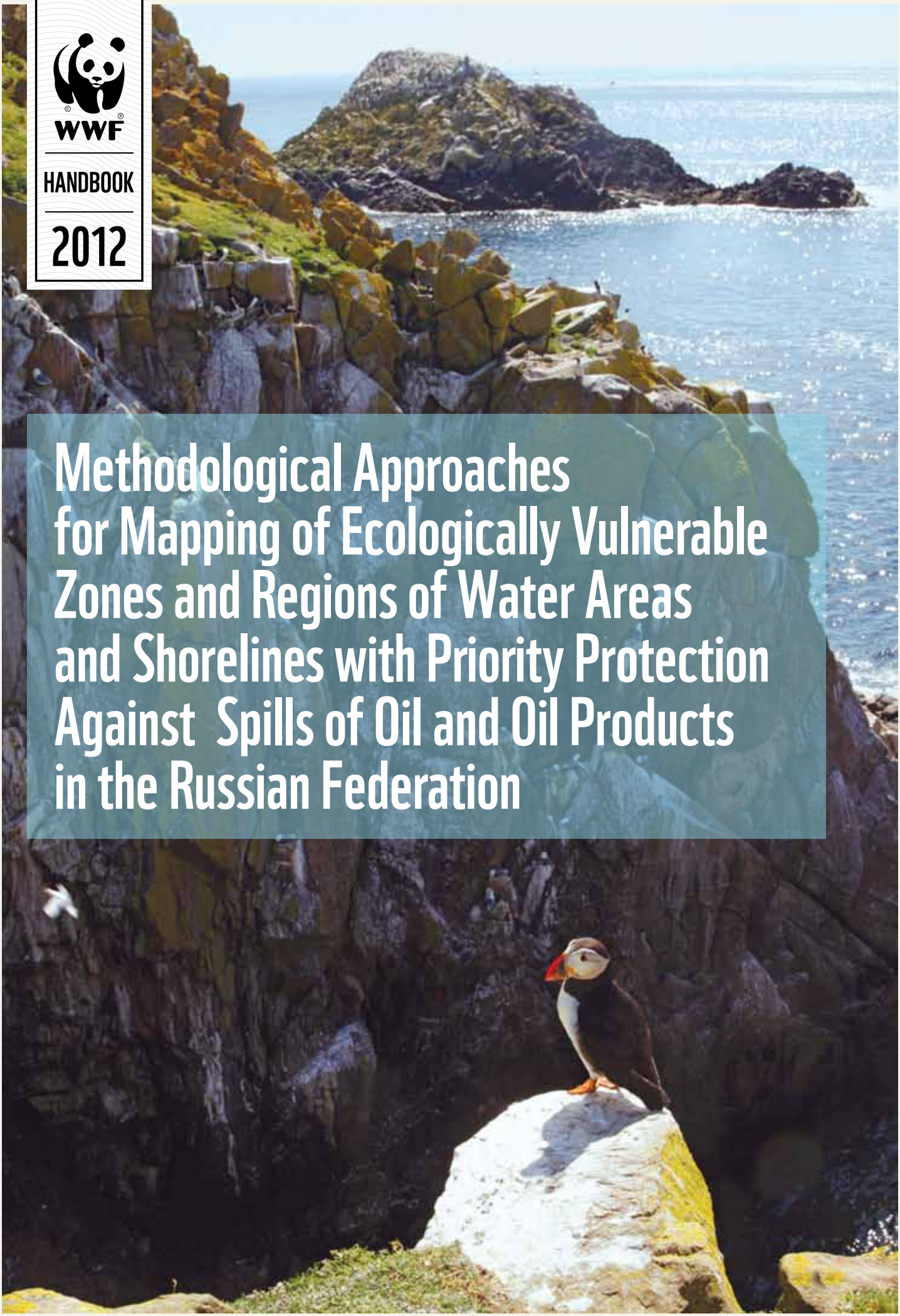
2012

Methodological Approaches for Mapping of Ecologically Vulnerable Zones and Regions of Water Areas and Shorelines with Priority Protection Against Spills of Oil and Oil Products in the Russian Federation



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Methodological Approaches for Mapping of Ecologically Vulnerable Zones and Regions of Water Areas and Shorelines with Priority Protection Against Spills of Oil and Oil Products in the Russian Federation

Vladivostok – Moscow – Murmansk – Saint-Petersburg

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The ‘Methodological Approaches’ for assessment of vulnerability of different marine and coastal ecosystems and priority objects to oil pollution were developed and agreed within the expert community. The leading experts in protection of marine environment from pollution were commissioned to do this work on the basis of the best international practice.

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ACRONYMS, DEFINITIONS AND TERMS

Acronyms

EPPR	The Emergency Prevention, Preparedness and Response Working Group. One of the working groups under the auspices of the Arctic Council established in 1996 to promote for international cooperation on protection of environment and sustainable development of the Arctic region
ESI	Environmental Sensitivity Index [shorelines]
EWG	Expert working group
FZ	Federal Law
GIS	Geographic information system of spatial data is the automated information system for processing of spatial and temporal data integrated on the basis of geographic data
IMO	The International Maritime Organization established under the auspices of the UN. Russia joined in 1958
INSROP	International Northern Sea Route Programme to assess the opportunities of its commercial use as it is understood at present (1993-1999). Russia was one of major stakeholders together with Norway and Japan
IPIECA	International Petroleum Industry Environmental Conservation Association. The mission of the organization is developing, sharing and promoting for the best practices and solutions associated with environmental and social performance
IUCN	International Union for Conservation of Nature
NGO	Non-governmental environmental organizations
OSR	Oil spill response is a set of measures to contain, collect and/or utilize oil released to the surface of water or land
SPNA	Specially protected nature area
VEC	Valued Ecosystem Component (VEC) is a natural component of specific ecological, economic or socio-cultural value. VECs that may be affected by certain aspects of an activity in question (oil spill in this case) are considered within the framework of the impact assessment (sensitivity to oil spill is assessed, thematic maps are developed)

Definitions and Terms

Benthos	Bottom plants and animals
Biocenoses	Biocenoses is the totality of plants, animals and microorganisms inhabiting certain area of land and water with specific interactions both among the organisms living together and abiotic aspects of their environment
Biota	Biota is the historically developed total collection of organisms of a geographic region. The biota includes plants, animal, fungi, bacteria, protists, viruses and microorganisms
Biotope	Biotope is an area of land or water with uniform abiotic conditions (relief, soil, climate, etc.) occupied by certain biocenoses
High priority areas	Areas that are important because of their economic, ecological and/or aesthetic value as well as areas that are the most vulnerable to oil contamination
Integral vulnerability	The result of summation of vulnerabilities of land or water areas for separate groups of plants and animals, taking into account their individual vulnerability to concrete impact, recoverability (reparative capacity), as well as spatial and seasonal distribution
Macrophytes	Large multicellular algae (green, blue-green, red) and marine vascular plants
Marine coastal ecosystem	An area within natural, artificial or conventional borders characterized by the presence of interacting with each other marine environment and coasts with associated biological communities and resources, including historic and cultural features as well as infrastructure supporting human activities
Oil	Petroleum in any form including crude oil, fuel oil, sludge, oil refuse and refined products
Oil Spill Contingency Plan (OSCP)	The document drafted by organizations involved in survey of oil fields, extraction and processing of oil, transportation and storage of oil and oil products to provide for timely measures for oil spill prevention as well as to maintain permanent preparedness of capacity needed to liquidate the spill in order to provide the safety of the population and territories as well as to keep the damage and loss from the spill to the possible minimum
Recoverability (reparative capacity)	The capacity of a biotope, community or population (that is key components of an ecosystem) to recover the status it enjoyed prior to the impact resulting from an activity or event that caused the change
Sensitivity	The capacity of an organism to respond to impacts from its environment, its ability to withstand external stress
Spatial data	Data on objects with spatial characteristics including information on their location and characteristics, spatial and non-spatial attributes. Normally include to interrelated sets on information: data on position in space and data not related to the position, that is the description of geographic location and thematic content data, topology and geometry as well as attributed details
Vulnerability	The inability of population, community to withstand the effects of a hostile environment. The vulnerability is in direct variation with the sensitivity of individual organisms of a population or community and in inverse variation with their capacity to recover
Vulnerability maps	Maps of ecologically vulnerable zones and water areas and shorelines subject to priority protection from oil spills

1. INTRODUCTION

Organizations involved in operations with oil and oil products (survey of oil fields, extraction, transportation, storage, cargo operations) to provide for efficient measures for oil spill prevention and response according to the Resolution of the Russian Federation Government No. 21 as of 21.08.2000 shall develop for each their object a plan for prevention and liquidation of spills of oil and oil products (hereinafter OSCP). The Russian Federation Ministry of Transport within the framework of All-Russian network of response to emergency situations additionally develops OSCPs for marine areas of regional and federal level. One of the key elements of an OSCP is a chapter covering the management of oil spill liquidation operations where the algorithm of decision making is presented. International experience of oil spill response demonstrates that the ability to take optimum decisions depends on availability of reliable oil spill behavior forecast and information on the area affected, or likely to be affected, by oil spill. Such information may be derived exclusively from maps of environmental vulnerability that allow to spot sites or areas of the coast calling for priority protection and prevention of pollution by oil spill. Such maps are developed as the mandatory supplement No. 1 to OSCP (scope of the plan in space and location of hazardous objects of organizations with borders of zones with high risk and areas for priority protection - Order of the Russian Federation Ministry of Emergencies No. 621). The need in such maps arises at the stage of feasibility studies for projects related to the development of objects of oil extraction, storage and transportation.

At present there is no generally accepted methodology for development of such maps in the Russian Federation. As the result, maps developed by different experts on certain occasions demonstrate significant differences and different amount of data presented. The purpose of the present document is development and co-ordination between the expert community and authorities involved of “Methodological approaches” to the assessment vulnerability of different components of marine environment to oil spills as the basis for the development of Environmental Vulnerability Mapping Guidelines. The work is initiated by WWF-Russia. The leading experts in protection of marine environment from pollution, biology and ecology were commissioned to do this work on the basis of the best international practice. The expert group includes Ya.Yu. Blinovskaya, Dr.Sc. in Technical Sciences (the Admiral G.I Nevelskoy MSU), M.V. Gavrilo, PhD in Biology (AARII), N.V. Dmitriev (JSC «Ecoproject»), A.Yu. Knizhnikov (WWF-Russia), V.B. Pogrebov, Dr.Sc. in Biology (JSC «Ecoproject»), A.Yu. Puzachenko, PhD (JSC «Ecoproject»), M.A. Pukhova (WWF-Russia), G.N. Semanov, PhD in Chemistry (CNIIMF), S.M. Usenkov, Dr.Sc. in Geology and Mineralogy, Prof. (JSC «Ecoproject»), M.B. Shilin, PhD in Biology, Dr.Sc. in Geography, Prof. at RSHU.

THE VULNERABILITY OF NATURAL OBJECTS TO SPILLS OF OIL AND OIL PRODUCTS DEPENDS ON PECULIARITY OF PHYSICAL GEOGRAPHY AND ECOLOGY OF THE SHORE-SEA ZONE

The vulnerability of natural objects to spills of oil and oil products depends on peculiarity of physical geography and ecology of the shore-sea zone. Therefore the conservation and protection needs of natural objects and coastal zone infrastructure elements are prioritized in accordance with the Russian law.

The “Methodological approaches” are developed in line with national environmental law and relevant international instruments applicable in the Russian Federation including:

- Federal Law No. 7-FZ “On protection of environment”;
- Federal Law No. 33-FZ “On specially protected nature areas”;
- Federal Law No. 52-FZ “On animal world”;
- Order No. 621 of the Russian Federation Ministry of Emergencies “On approval of the rules on development and endorsement of oil spill prevention and response plans on the territory of the Russian Federation”;
- Federal Law No. 166-FZ “On fisheries and conservation of aquatic biological resources”.

More detailed description of Russian legal requirements on development of maps of ecologically vulnerable zones and priority protection water areas (hereinafter integral vulnerability maps) and shorelines from oil spills is presented in Appendix 1.

The “Methodological Approaches” draw at large on methodology developed by the International Petroleum Industry Environmental Conservation Association (IPIECA) and approved by the International Maritime Organization (IMO, Russia being a member thereof) in 2012 (IMO/IPIECA, 2012). The most advanced Russian and international developments are employed as well (see References).

2. PURPOSE AND SCOPE OF THE 'METHODOLOGICAL APPROACHES'

This document presents methodological background and practical recommendations on mapping of ecologically vulnerable zones and areas of priority protection of water areas and shorelines from oil and oil products. These are meant for organizations involved in planning and implementation of operations on clean-up of accidental oil spills, including experts of basin salvage units of the Ministry of transport of the Russian Federation and regional units of federal executive organs responsible for state management in the sphere of environmental protection and control, persons effecting management of oil spill response operations. The document also addresses the needs of different competent organizations: state bodies of different level, research and educational institutes, environmental agencies, environmental NGOs and others.

Producing of maps of integral vulnerability is an essential step in prevention, preparedness and response to emergency situations. The main goal of such mapping is the development of tactics and strategy of actions of oil spill responders. Maps of ecologically vulnerable zones provide the basis for taking optimum decisions while tackling the accident. This document is not meant for estimation of economic loss, assessment of damage and compensations.

3. GENERAL PROVISIONS AND REQUIREMENTS TO MAPS

All thematic and summary maps of vulnerability shall be developed on the basis of topographic maps of relevant scale as well remote sensing data. At the initial stage *electronic* maps shall be considered. This requirement stems from huge volume of data and broad range of topics to be reflected, the need for update (this is particularly true as new data on status of environment emerge and new facilities appear).

The mandatory layers of the basic topographic map shall be the following:

- land and bottom relief;
- water courses;
- hydro engineering facilities;
- settlements;
- industrial, agricultural, social and cultural facilities;
- ways of access and road network;
- plants, land and soil of coasts;
- limits of SPNA (to determine precise borders of SPNAs at the stage of mapping it is recommended to use information provided by state authorities responsible for specially protected nature areas).

3.1 Categorization of the objects in question and requirements to content of maps

The IMO/IPIECA (2010) approach to mapping is carried out by considering three sensitivity themes together with one response theme:

(1) type of shoreline and its integral vulnerability to oil spill;

(2) vulnerable biotic components/valued ecosystem components (VEC);

(3) vulnerable elements of social and economic infrastructure;

(4) facilities of logistics and operational response to oil spill.

Russian legislation recognizes the following objects and areas specifically vulnerable and subject priority protection:

- Objects subject to special protection (Federal Law of January 10, 2002 No. 7-FZ “On environmental protection”);
- specially protected nature areas (Federal Law of March 14, 1995 No. 33-FZ “On specially protected nature areas” as amended on August 22, 2004);
- priority protection areas (Order No. 621 of the Russian Federation Ministry of Emergencies of December 28, 2004 “On approval of the rules on development and endorsement of oil spill prevention and response plans on the territory of the Russian Federation”);

THE SHORE AS THE DIVIDE BETWEEN LAND AND SEA IS THE BARRIER FOR SPREAD OF OIL SPILL WHEREAS ACCUMULATING OIL AND PRODUCTS OF ITS TRANSFORMATION IF OIL SLICK HITS THE COAST

Analyses of oil spills at sea demonstrates that accidents produce the most devastating effects in coastal zones and shallow water areas (Patin, 1997). The shore as the divide between land and sea is the barrier for spread of oil spill whereas accumulating oil and products of its transformation if oil slick hits the coast. That is why there is special focus on shorelines; special thematic maps are produced for them (see Section 8).

The coastal zone normally presents a concentration of most important objects, zones and areas that call for top level protection from spill of oil and oil products as discussed earlier. Apart from specific areas (SPNA, objects of UNESCO World Heritage, areas sensitive from social and economic perspectives) Russian legislation states that 'key habitats' are subject to protection as well. Coastal and vast water areas host such important ecosystem components as algae and invertebrates, Metaphyta, fish, amphibians and reptiles (VEC; INSORP, 1996, 1998 a-c). These groups of organisms are subject to priority protection for both being vulnerable by nature and of value in terms of ecology, society, economy, conservation. The peculiarities of producing thematic maps of VEC distribution with account of temporal characteristics of biological and natural phenomena are presented in Section 5.

Thus thematic maps shall contain the following information (thematic layers):

(1) data on location of objects, zones and areas subject to protection pursuant to cited above legal instruments;

(2) data on spatial and temporal (season specific) distribution of VEC throughout water area and coast.

It is recommended to produce separate maps of vulnerability of shoreline (see Appendix 3).

3.2 Layout and representation of information

Summary maps shall be preferably presented as an atlas, specific maps (sections) shall be accompanied by explanatory notes. It is expedient to follow generally accepted order of presenting information while describing VEC and areas in question. This suggests providing details of objects in question starting from non-biotic components, then biological objects to be followed by different aspects related to human activities. Monographs by Russian and foreign experts, latest publications and electronic databases, data of monitoring, including remote sensing data, are recommended as references.

The content of maps in an atlas shall meet the requirements to cartographic materials in relevant departments of natural sciences (geography, hydrobiology, ichthyology, zoology, etc.). The maps shall be suitable for practical use by major user groups and, primarily, for oil spill responders. The latter need brief and understandable maps free of unnecessary details that distinctly indicate clean-up priorities in emergency situation. Schematic maps with 'traffic lights' legend (red, yellow, green and shades thereof) indicating the value of an object and priority of its protection meet these requirements best. To differentiate distinctly the level of vulnerability of different areas 5 colors coding is preferable.

3.3 Scale of maps

Different users my refer to integral vulnerability maps for different purposes — from developing response strategy, optimizing infrastructure location, logistic support of clean-up actions to operational decision making in case of local level accident. Therefore, depending on the purpose and oil spill tier the user will need maps at different scale. Normally maps of three range of scales are used:

- **general plans** (at a scale ranging from 1:10 000 to 1:25 000, e.g. for Tier 1 accident and clean-up of a certain part of the shoreline);
- **large scale** (at a scale from 1:25 000 to 1:100 000);
- **small and medium scale** (at a scale from 1:100 000 to 1:1 000 000, e.g. to address the needs at the initial stage of clean-up of Tier 3 oil spill or planning of location of oil response facilities).

Scale must be presented linearly, i.e. shown on the map as a bar scale, to preserve precise information on the scale even if the original map size will be modified in the course of copying.

Maps shall be produced on the basis of data obtained from thematic maps of relevant scale (scale coordination principle). In other words, it is unacceptable to paste a part of an integral vulnerability map produced for the whole sea, enlarge it in and apply to a tactical map of a corresponding bay or detailed map of an oil terminal. As the level of detail is attributed to specific scale, preservation of original level of detail cannot provide information required from the map of a larger scale. To produce maps at a smaller scale one also needs 'specific' thematic maps as the basis for 'specific' integral maps that may be derived from maps of a larger scale by generalization.

MAPS SHALL BE PRODUCED ON THE BASIS OF DATA OBTAINED FROM THEMATIC MAPS OF RELEVANT SCALE (SCALE COORDINATION PRINCIPLE)

Scale coordination principle

To develop maps of integral vulnerability at a certain scale only the data (layers) obtained within a thematic map of relevant scale shall be used. Mechanical enlargement of scale of maps is unacceptable. Reducing of maps to obtain smaller scale shall be accompanied by generalization.

4. PROJECT MANAGEMENT. QUALIFICATION OF DEVELOPERS OF MAPS

Multidisciplinary nature of information and level of detail required for development of thematic and summary maps of vulnerability suggests step by step approach and input of experts with different background. *Expert working group (EWG)* is established at this stage and project implementation plan is developed.

Different competent organizations may serve as developers:

- state bodies of different level;
- research and educational institutes;
- environmental agencies;
- environmental NGOs and others.

EWG shall include (or seek advice from) experts in oceanology, geology, geography, biology, conservation, geographic informational systems (GIS), hydrocarbons chemistry and oil spill clean-up. The availability of GIS expertise for EWG deserves special attention. GIS at present is the most efficient tool for collection, storage, analysis and graphic visualization of spatial and related data on objects presented in GIS.

Such software products as ArcGIS or MapInfo being convenient tools with high performance are recommended for tackling wide range of tasks related to mapping vulnerability and prioritizing protection of water areas and shoreline.

Invitation of experts to EWG is the responsibility of the project owner. It is perceived as the most expedient to way forward when EWG includes experts possessing, on the one hand, *practical experience* of assessing vulnerability of water areas and shoreline to oil spill, and, on the other hand, *experience of field research* in the area in question (empirical knowledge priority principle). The latter consideration is quite important as information on peculiarity of coasts, local communities of animals and plants are seldom present in literature sources or archives. Such information however is critical for *region specific correction* of weighted parameters determining vulnerability coefficients as well as for the selection of phenological seasons (regionalization principle, see Section 7.1).

Empirical knowledge priority principle

It is always best to safeguard the involvement of both experts with personal practical experience of assessing impact of oil spills on environment and objects of socio-economic importance, and experts with personal experience of field research in the area in question. This allows for further correction of vulnerability coefficients, select phenological seasons depending on natural and climatic peculiarities of area under study as well as update information reflected in large scale maps.

EWG pursuant to requirements established by legal sources and principles of VEC selection decides on the list of necessary layers of biota to be reflected on maps of ecologically vulnerable areas and areas for priority protection within the area in question. More experts are invited on specific objects included in the list of thematic mapping as the situation requires if experts with relevant experience and expertise are missing from the existing EWG.

It is recommended to conduct prefatory consultations with experts of state environmental protection agencies and general public to account for issues of importance for regional authorities and local community and thus avoid complications that might otherwise arise when OSCP is submitted for approval.

5. DEVELOPMENT OF SEASON SPECIFIC VULNERABILITY MAPS OF VALUED ECOSYSTEM COMPONENTS (VEC)

5.1 Selection of seasons

Mapping of biological resources shall account for temporal aspects of development of biota and life and year cycles of animals (reproduction, migration, molting, etc.). The climate of the Russian Federation and its seas in the North (most being located north of 50° N) is cold at large. Its peculiarities are express seasonality and corresponding succession of season specific biological phenomena. Normally four seasons are distinguished: winter, spring, summer, autumn. All of the above seasons are most distinctly expressed in areas with moderate climate. As far as the Arctic is concerned long winter and short summer are observed whereas spring and autumn may be missing. It is natural, that certain seasons do not necessarily last for three months. Meanwhile shift to another season may not coincide with calendar dates depending on natural and climatic conditions of the site.

Seasonal ice formation in water areas of the freezing seas is a critical factor for all biological processes. Life and annual cycles characteristic of biota account for different vulnerability of species and communities throughout a year so that organisms demonstrate different sensitivity whereas communities demonstrate different vulnerability to oil spills depending on a stage of the cycle. Migration activity of most species of biota demonstrates season specific spatial distribution due to the seasonal aspect of climate.

Seasonal aspect, however, is an important factor for deciding on measures to be taken in the course of clean-up of oil and oil products. On the one hand, it stems from the conditions of clean-up actions, and on the other hand it is related to different ecological vulnerability of areas. The latter depends on the presence and the condition of ice and season specific biological phenomena.

SEASONAL ASPECT, HOWEVER, IS AN IMPORTANT FACTOR FOR DECIDING ON MEASURES TO BE TAKEN IN THE COURSE OF CLEAN-UP OF OIL AND OIL PRODUCTS

To produce seasonal maps of distribution of biota in the area under study *the seasons must be specified*, their limits should be determined with regard to regional peculiarities. Meanwhile, for the sake of better precision and subject to availability of required data and resources maps may be developed on *monthly basis*.

Thematic maps are then produced for each season (see 5.4).

Accuracy in determining duration and time limits of the season may be regarded as acceptable with variance up to a decade.

5.2 Information reflected on thematic maps: selecting VEC

Valued ecosystem component is a natural component of ecosystem which stands out among its various components on account of its specific environmental, economic or socio-cultural importance. Set of VEC distinguished within an ecosystem in question is conditioned by the structure, composition, functional relationships and considerations of use (different types of exploitation of biological resources) thereof. The selection of VEC is performed by the expert group after analysis of available material and the choice is made on collegiate basis.

Selected VECs are assessed on vulnerability to oil spill and maps of their seasonal distribution are developed.

The IMO/IPIECA methodology (2010) regards as vulnerable areas ecologically important or endangered biotopes, nesting areas, stopovers of migrating animals, etc. (i.e. VECs concentration sites). The following groups are considered as vulnerable organisms:

- phyto- and zooplankton;
- macrophyte algae (especially species used for human consumption, technological or pharmaceutical purposes: *Ahnfeltia*, *Laminaria*, *Fucus* and other brown algae);
- invertebrates, first of all bottom species – benthos (commercial mollusks and crustaceans, endangered species);
- fish (spawning and juveniles concentration areas, areas of distribution of coastal and commercial pelagic species);
- birds (first of all, seabirds, and also sea dependent waterfowl and birds living near water);
- marine mammals (whales, dolphins, seals, walruses) and mammals linked ecologically to the sea (Polar bear, sea otter);
- coastal vegetation (submerged and semi-submerged plants, trees and bushes);
- marine and coastal amphibians and reptiles;
- terrestrial vertebrate species ecologically (via biotope or trophic relations) connected with sea coast (birds of prey and such mammals as mink, Polar fox, wolf, bear and others);
- IUCN red listed species, species included into Red Books of the Russian Federation or its subjects.

It is recommended to pay special attention to rare and protected species (IUCN red listed species, species included by competent authorities into Red Books of the Russian Federation or its subjects). These species shall be mapped even if their populations demonstrate relatively low vulnerability to oil pollution especially for considerations of possible disturbance of their habitats by clean-up activities.

The set of maps shall be substantiated from the ecosystem approach perspective and compiled in a manner reflecting the integral nature of a regional marine ecosystem.

The assessment carried out at this stage therefore shall result in the *compilation of the list of VECs* to be reflected further in thematic maps presenting peculiarities of their spatial distribution. That is to say *the list of maps* to be used in the course of assessment of integral vulnerability of the water area is determined.

5.3 Reliability of data on species and groups of organisms vulnerability

To assess the sensitivity of organisms and the degree of vulnerability of their populations and communities available scientific data shall be put through the test in

an unbiased manner, as *confidence* of data is important. To make the right decision the experts involved shall refer to most authoritative and modern literature reflecting results of research and reliable sources of information. Moreover, they must be prepared to test the quality of their own assessment. It is noteworthy that *resulting coefficients should be based on registered evidence.*

To formalize the procedure of quality assessment it is advisable to refer to the supplementary tables presented in Appendix 5.1.

In some cases lack of data may render vulnerability assessment and mapping impossible.

MAPS ARE DEVELOPED BY ESTABLISHED SEASONS SO THAT SPATIAL AND TEMPORAL PARAMETERS OF DISTRIBUTION OF VECS ARE SHOWN WITHINTHE WATER AREA AND SHORELINE IN QUESTION

5.4 Peculiarities of mapping and ranging of thematic maps of VEC distribution

Biological objects (VEC) selected by experts at earlier stages are mapped by established seasons so that *spatial and temporal parameters of distribution of VECs* are shown within the water area and shoreline in question. Experts define and communicate the list and substance of parameters used to the project coordinator. An expert, for example, may describe *general* season specific vulnerability of the water area throughout year for fish or birds. It suggests significant simplification of actual data (e.g. due to the need to present in one map developed for the specific season the distribution of several communities whose seasonal phenomena may differ in time of occurrence).

Many marine biology sources indicate deficit of source data on distribution throughout water areas of such groups of marine organisms as fish, sea birds and marine mammals. Moreover, due to innate dynamics of aquatic environment as such mapping of the distribution of its mobile inhabitants is quite challenging. Therefore it is advisable to consider areas of potential presence of mobile objects when they are mapped and determine maximum but not extreme distribution. Similarly, whenever source data on some species distribution are missing for certain sites of water areas it is preferable to mark the limits of its potential distribution on the basis of knowledge of its biological features than to conclude the absence (precautionary approach). Thus, for example, when data on occurrence of sea ducks in polynyas in spring are missing it is advisable to mark areas with polynyas as temporary habitat in pre-nesting period, as sea ducks are known to come to the tundra just before nesting whereas in spring they fly over the sea and need open water for rest and feeding.

WHENEVER SOURCE DATA ON SOME SPECIES DISTRIBUTION ARE MISSING FOR CERTAIN SITES OF WATER AREAS IT IS PREFERABLE TO MARK THE LIMITS OF ITS POTENTIAL DISTRIBUTION ON THE BASIS OF KNOWLEDGE OF ITS BIOLOGICAL FEATURES THAN TO CONCLUDE THE ABSENCE

Season specific maps of distribution of assessed species and groups of organisms in the area in question shall be produced in the layout which is traditional for corresponding disciplines. While adding content to maps the generally accepted terms for description of a species or group of organisms are used (in g/m^2 for benthos, t/per trawling hour, ind/km^2 or 'high-medium-low-occasional' for birds and mammals, 'present-absent' for reedstand or coastal macrophytes, etc.).

Ranking of abundance used by experts depends on the whole on nature and completeness of available data. Ranking may be based on two (the object is either present or absent) or more ranks (e.g., abundance of biomass of benthos or concentration of birds across a water area may be ranked using deliberately

selected number of ranks). Using more than 5-8 ranks (for the whole year) is impractical.

Consistence of legends in thematic maps shall be maintained throughout maps for different seasons (hachure methods, color scale, standardized symbols). That is to say, they shall be *the same for the whole year*. This facilitates assessment of seasonal dynamics through comparison of maps. Total number of thematic maps produced at this stage of mapping varies from 20 to 50 and covers 10 to 50 species or groups of objects. Thematic maps describing spatial and seasonal dynamics on monthly basis may be developed subject to availability of sufficient funding, full range of expertise and data.

6. MAPPING AREAS FOR PRIORITY PROTECTION

Objects of socio-economic importance are defined at this stage to be integrated into vulnerability maps. The methodology of IMO/IPIECA (2010) recognizes several types of objects supporting the following activities:

- fishing grounds of artisan fisheries, commercial fisheries, harvesting of sea products, sealing;
- aquaculture;
- use of water (desalination plants, salt evaporation, industrial facilities water intakes);
- tourism and recreation (hotels, restaurants, boat harbors, beaches, recreation fisheries, rehabilitation, resort and diving areas);
- activities of sea terminals;
- industry (particularly those dependent on sea transport);
- energy production (nuclear power stations, hydro power plants, tidal power plants, etc.);
- mining infrastructure associated with prospecting, extraction and transport of hydrocarbons;
- sites of cultural and historical heritage.

Mapping of areas for priority protection suggests mapping of red listed species regardless of seasonality of their occurrence.

MAPPING OF AREAS FOR PRIORITY PROTECTION SUGGESTS MAPPING OF RED LISTED SPECIES REGARDLESS OF SEASONALITY OF THEIR OCCURRENCE

This category of objects also includes protected areas, both existing and planned. It is expedient to show them on maps as they normally host high concentrations of life and therefore need to be specially protected.

SPNAs and the objects of historical and cultural heritage may be of international, federal, regional or local significance and it is advisable to take it into account while defining priorities of protection. Samples of thematic maps of areas for priority protection from oil spills within shorelines and water areas are presented in Appendix 4.

7. MAPPING INTEGRAL VULNERABILITY

According to the 'Methodological Approaches' all information from the whole series of thematic maps shall be integrated into maps of integral vulnerability of the area in question:

- maps of distribution of selected VECs;
- SPNAs of different types (including the ones to be established in future);
- important and vulnerable socio-economic features (areas for priority protection);

Information on ecological sensitivity of shoreline is used to produce shoreline vulnerability maps. The challenges of including the information on ecological vulnerability of shorelines into maps of integral vulnerability of a water area are caused by the fact that in the course of integration of all layers, regardless of scale of maps, the shoreline is though important yet always negligibly narrow. Consequently the developers of OSCP prefer to get separate maps of shoreline sensitivity.

7.1 Determination of VEC vulnerability and areas for priority protection (PPA)

Vulnerability indices for VECs and PPA protection priorities are determined at this stage.

Ranking of the protection priorities is performed by EWG on the basis of auxiliary materials presented in Appendix 5.3 whereas the need for protection of each object is ranked (from 1 to 5).

When vulnerability of species or groups of organisms is performed it is advisable to account for *(1) the sensitivity of constituent organisms* and *(2) the ability of their populations to recover. Vulnerability coefficient* is determined on the basis of the table (see Appendix 5.3). Attributing of coefficients shall be based on scientifically sound data on the influence of various types of oil on VECs.

When assessing the vulnerability of species or groups of organisms to oil spills *the peculiarities of behavior of different types of oil in water* shall be considered. Light oils (benzene, diesel fuel) evaporate easily; oil of medium density quite easily emulsifies and turns into highly viscous sour cream like emulsion floating on sea surface. Heavy oils (residual oil) in water with reduced salinity may sink or float under the surface. These differences in behavior of different types of oil suggest different types of impact on environment. The probability of contact with an oil slick for animals living at different depths will particularly depend on properties of oil. If an OSCP provides for the use of dispersants then the impact of both surface oil slick and oil emulsified in the water column must be considered.

WHEN ASSESSING THE VULNERABILITY OF SPECIES OR GROUPS OF ORGANISMS TO OIL SPILLS THE PECULIARITIES OF BEHAVIOR OF DIFFERENT TYPES OF OIL IN WATER SHALL BE CONSIDERED

Information on oil behavior under the circumstances relevant for VECs and PPA (the duration of oil being floated on surface, in water column and its stay on bottom following submersion) may be drawn from the OSCP that the maps are to be integrated with, and also from Russian or foreign monographs.

The vulnerability of species/populations or groups/communities of organisms *is in direct variation to the sensitivity of organisms and inverse variation to the ability of their populations to recover.* That is to say that species or groups of organisms

THE VULNERABILITY OF SPECIES/ POPULATIONS OR GROUPS/COMMUNITIES OF ORGANISMS IS IN DIRECT VARIATION TO THE SENSITIVITY OF ORGANISMS AND INVERSE VARIATION TO THE ABILITY OF THEIR POPULATIONS TO RECOVER

may demonstrate high sensitivity yet their populations are capable to recover soon (plankton). Therefore their vulnerability will be relatively low. Other species or groups of organisms are both highly sensitive and need many years to recover (birds and mammals). If rare species or an isolated population (that stands little chance to recover through outside migration) are impacted the recovery of such a population is very problematic on the whole.

Regionalization principle

Regionalization is correcting coefficients of VEC and priorities of protection of water areas and shores depending on natural and climatic peculiarities of the area under study and region specific socio-economic features.

It is important to account for region specific features of natural and climatic conditions (selection of seasons), populations and communities (protection status, peculiarities of behavior, abundance dynamics, distribution across biotopes, migration patterns, etc.), socio-economic factors (the distribution and nature of traditional use of nature, other resources dependent activities). Due consideration of these factors produces region specific estimates of sensitivity, ability to recover, vulnerability and protection priorities, that is regionalization of expert coefficients.

Precautionary principle is crucial for attributing coefficients and establishing hierarchy of priorities. The precautionary principle goes as follows.

Precautionary principle

In case of missing objective data to support the decision on attributing coefficients or establishing hierarchy of priorities for mapping purposes one should decide 'in favor of the object'. That is to say that in assessment of sensitivity, ability to recover or vulnerability it is preferable to use higher coefficient than to find out that an oil spill affected population or community recovers much slower than an expert expected. It holds good for prioritizing areas subject to special protection. Similarly, if source data on distribution of a species are missing it is preferable to assume its presence in the area on the basis available knowledge of its biology than to make conclusion on its absence.

Interim results of assessments of VECs obtained and priorities for the protection of specific areas (water areas and shores) from oil spill set the full expert board commences to discuss the summary coefficients table.

Estimates of VECs' vulnerability and priorities for the protection of specific areas following the regionalization procedure, account for parameters of potential oil spill shall be carried out (1) with the participation of all stakeholders and (2) continue until consensus is reached.

Due to the lack of objective data on vulnerability of VECs it is necessary to refer to best knowledge available internationally and foster research activities in relevant fields in Russia.

7.2 Ranging integral vulnerability

An important stage in establishing vulnerability of VECs and priorities for protection of areas is the selection of scale of ranking. Assessment of shorelines vulnerability on the basis of ESI suggests ranging from 1 to 10 (see Section 8). The IMO/IPIECA (2012) methodology contains ranging of shore types from 1 to 21 whereas 15 colors scheme is used for representing them on maps (Appendix 3).

The application of ESI is based on the following criteria:

- sensitivity of the shoreline to oil (in inverse variation with the level of exposure to waves);
- the capacity of oil to penetrate bottom sediments;
- time of the natural persistence of oil on the shoreline;
- biological productivity of organisms associated with coast.

It is best to range the vulnerability from 1 (very low) to 5 (very high).

7.3 Technical aspects of integral vulnerability mapping

Integration of layers from separate thematic maps and establishing contours of vulnerability 'concentrations' are suggested by the IMO/IPIECA (2012) methodology, too. However, it leaves ranging of protection priorities to the discretion of the developers of the integral map.

To integrate thematic maps in GIS *the relative vulnerability of ecosystem components and priority for protection of water areas and shorelines from oil spills* as estimated by experts at earlier stages is required (see above and Appendix 5).

THE INTEGRAL VULNERABILITY OF AN AREA IS DETERMINED AS A SUM OF (1) PRIORITY OF PROTECTION OF REGIONS (AREAS) OF WATER AREAS AND SHORES, (2) VULNERABILITY OF WATER AREAS AND COASTAL ZONES, BASED ON TOTAL VULNERABILITY OF VECS WITHIN THEIR LIMITS

It is noteworthy that any objects or components of inshore or coastal areas are represented either on season specific maps (the majority of biological objects, some socio-economic facilities) or as unaltered throughout year (some biological objects, historical and cultural heritage, SPNA, most of socio-economic facilities and element of infrastructure) depending on their properties.

The integral vulnerability of an area is determined as a sum of (1) priority of protection of regions (areas) of water areas and shores, (2) vulnerability of water areas and coastal zones, based on total vulnerability of VECs within their limits.

In this case the quantitative estimation of the integral ecological vulnerability of the area will demonstrate spatial and temporal variations associated with seasonal dynamics of vulnerability of VECs and priority of protection of certain socio-economic facilities (e.g., beaches and harbors).

Shoreline vulnerability maps are produced separately.

To determine the integral vulnerability of a VEC to map a species/species group a separate GIS based layer (thematic distribution map) is developed.

Background maps to be processed in GIS environment are presented as polygonal shape-files, cells (polygons) are established for ranging of distribution of abundance (biomass) of selected VECs. Information on *the distribution of objects* (abundance

THE RESULTS ARE PRESENTED AS A SERIES OF MAPS (NORMALLY, EACH SET INCLUDES FOUR MAPS: SPRING, SUMMER, AUTUMN, WINTER)

indicators) is to be defined for every cell of each thematic map. Then season specific data on the presence of an object in the given area or its abundance indicators are entered into the fields of the properties table for each object of a thematic layer.

Initial integration of maps is carried out for the group of VECs with similar vulnerability coefficients. For example, maps of the distribution of all vascular plants (vulnerability ranges from 3 to 4) or birds of prey associated with coast (vulnerability ranges from 1 to 2).

Then *data on the distribution of the objects in every cell are multiplied by the vulnerability coefficient attributed to the corresponding group of VECs.*

Further, the integration of summary maps for VEC groups is carried out.

All layers derived separately for biota and PPA are integrated.

In this case cells obtain different values from minimum (e.g. 20) to maximum (e.g. 1500). Summary vulnerability indices obtained for each cell are ranged into 5 groups based on expert opinion.

The results are presented as a series of maps (normally, each set includes four maps: spring, summer, autumn, winter). The integral vulnerability of the area on maps is represented in 5 colors coding from red ('very high vulnerability') to green ('low vulnerability') through yellow ('medium vulnerability'). The maps are strictly standardized, understandable, represent spatial and temporal vulnerability and do not require expert knowledge from decision makers to interpret them.

Step-by-step algorithm of developing maps of integral vulnerability is presented in Appendix 6. Sample maps of integral vulnerability of water areas are shown in Appendix 7.

7.4 Interpreting integral vulnerability maps

A set of maps of integral vulnerability of the water area in question facilitates the analysis of dynamics of this parameter in space and time during the year within the area under study. The project is crowned by the general analysis of summary maps. The most vulnerable sites (areas) of water area and seasons are determined. The recommendations on most efficient ways to organize the protection of environment from potential spills of oil and oil products are developed. The results of such analysis may, in particular, help to optimize the location of infrastructure and the facilities of logistic and operational response to oil spills as shown below.

8. MAPPING SHORELINE VULNERABILITY

When accidents happen it is the natural environment of coastal zone that is most vulnerable to pollution by oil and oil products. When oil reaches land the pollution may impact tidal area from water line to the line of maximum (syzygial) tide or area above mean water line through normal wave action or storm. The influence of storm in some types of lowlands with developed hydrological network may occur several kilometers off shoreline itself. If oil reaches inshore water areas and shoreline the consequences will be grave and lasting whereas scenarios for the future will be much more diverse than for an oil spill in open water. Ranging of shores by the degree of their vulnerability to oil pollution according to the IMO/IPIECA (2012) methodology is ESI based.

According to ESI scale 10 major types of Russian shorelines are distinguished depending on their vulnerability to oil spills (see Appendix 3).

Maps of vulnerability of shorelines are presented in an atlas as thematic maps.

9. FEATURES OF LOGISTICAL AND OPERATIONAL RESPONSE TO OIL SPILLS ON MAPS OF THE INTEGRAL VULNERABILITY

Features of logistical and operational response to oil spills include the following:

- location of incident command posts and their geographical limits;
- existing stockpiles of ammunition and equipment (emergency response facilities);
- pre-approved dispersant areas and their geographic limit(s);
- areas supported by environmental recommendations on limiting the impact of oil and peculiarities of clean up operations (particularly important for highly sensitive areas);
- sites and centers of rehabilitation of impacted animals;
- sites for interim storage of waste.

These features are integrated into summary maps of vulnerability. They can also be presented as a separate layer in GIS where their location is updated as situation requires.

10. CONCLUSION

The *'Methodological approaches' draw at materials produced* and approved by IMO *(IMO/IPIECA, 2012)* where the Russian Federation is a party. They are supported in addition by 15 years of experience of the authors in mapping vulnerability for all seas of the Russian Federation within the framework of large international projects (INSROP) or were commissioned by organizations developing OSCPs for Russian and foreign oil companies.

COMPREHENSIVE MAPS OF THE INTEGRAL VULNERABILITY MAY BE PRODUCED ONLY BY AN EXPERT BOARD COMPRISING EXPERTS IN DIFFERENT DISCIPLINES

Comprehensive maps of the integral vulnerability may be produced only by an expert board comprising experts in different disciplines. The diversity of information required for producing maps of vulnerability and areas for priority protection suggests the involvement of experts in oceanology, geology, biology, geography and other areas. Therefore, establishing *an expert group* comprising established researchers and practitioners is critical for the development of maps.

The means of digital cartography shall be employed and the project *shall be performed in GIS environment.*

THE MEANS OF DIGITAL CARTOGRAPHY SHALL BE EMPLOYED AND THE PROJECT SHALL BE PERFORMED IN GIS ENVIRONMENT

Establishing of the expert board may be effected by governmental institutions of different level, research and educational center possessing required expertise, environmental agencies, NGOs or other organizations.

While producing maps of the integral vulnerability one should *observe certain principles* postulated in the course of development of these 'Methodological approaches'. The most critical ones are as follows.

- *Principles of regionalization and priority of practical knowledge*. Estimates of vulnerability and the ability to recover, coefficients of vulnerability of VECs, choice of areas for priority protection shall account for peculiarities of the region and preferably employ local expertise of professionals with the track record in the area under study.
- *Precautionary principle*. When the objective data are missing the worst case scenario shall be assumed and decision taken 'in favor of the object' based on such a scenario.
- *Scale coordination principle*. If necessary, separate maps at large scale shall be produced, enlarging of fragments of maps of a smaller scale for this purpose is unacceptable. Such erroneous practice does exist yet there are only few isolated cases where it is justified. The background of this recommendation though not obvious to many can be easily explained to general public by an expert.

To avoid bias in summary estimates independent expert opinion shall be obtained at the final stage. It is noteworthy that the integration of large volumes of heterogeneous data that undergo a series of ranging of selected indicators may result in accumulation of errors when summary maps are produced.

From socio-political perspective it is important to maintain at all stages of the project *communication with state environmental protection agencies* and their offices on the one hand, and, on the other hand, *with the public* (e.g., NGOs involved). *It*

is always useful to learn in advance, and not at after submitting of the document for approval, about concerns of local office of the federal authority responsible for environmental control, representatives of the authorities responsible for sanitary and epidemiological control, experts of fisheries agency, the general public living in the area for which OSCP is developed.

General lines along which mapping of the integral vulnerability may be approved are as follows:

- accumulation of knowledge on biology and patterns of temporal and spatial distribution of species and environmental impact of oil spills;
- obtaining in depth knowledge of impact of different types of oil on certain species and groups of organisms (to enhance reliability of their vulnerability assessments);
- building on the experience in mapping ecologically vulnerable zones and regions of water areas and shorelines with priority protection against spills of oil and oil products in Russia;
- assessment of correlation between the information presented on maps of the integral vulnerability and real consequences of oil spills in different parts of the Russian Federation and globally.

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APPENDICIES

APPENDIX 1.

Legal requirements in respect of maps of ecologically vulnerable zones and regions of water areas and shorelines with priority protection against spills of oil and oil products in the Russian Federation

1.1. Documents directly addressing the development of vulnerability maps

According to *the Russian Federation Ministry of Emergencies* order No. 621 of December 28, 2004 *"On approval of the rules on development and endorsement of oil spill prevention and response plans on the territory of the Russian Federation"* item 1 of Section V of Appendix 1 maps reflecting limits of *areas for priority protection* are mandatory and indispensable part of OSCP. Priority protection areas may be reflected in vulnerability maps.

Federal Law of January 1, 2002 No. 7-FZ *"On protection of environment"* is the key legal instrument prescribing environment related procedures in the Russian Federation. This Law lays down basic principles of administrative rules in respect of protection of nature components and systems thereof and provides the basis for determining *ecologically vulnerable zones*. The Law sets out rights and obligations of state authorities, users of nature and the public. According to Article 4 (3) of this Law the following objects are subject to special protection:

- the objects covered by the List of the World Cultural Heritage and the List of the World Nature Heritage;
- state strict nature reserves (zapovedniks), including the ones recognized as biosphere reserves, state nature zakazniks, nature monuments, national, natural and dendrological parks, botanical gardens;
- health rehabilitation areas and health resorts;
- other natural complexes;
- the original environment, areas of traditional residence and economic activity of small-numbered indigenous peoples of the Russian Federation;
- the objects of special value in terms of nature preservation, science, history and culture, aesthetic, recreational, health rehabilitation significance or for other reasons;
- the continental shelf and the exclusive economic zone of the Russian Federation;
- rare or being on the brink of extinction soils, rare or endangered forests and other vegetation, animals and other organisms and their habitats.

Protection standards related to specific components of environment are set out in relevant laws and regulations adopted in furtherance thereof.

Federal Law of March 14, 1995 No. 33-FZ *"On specially protected nature areas"* provides for establishment and management, protection and use of specially protected nature areas (SPNA) to preserve unique and typical natural complexes and objects, formations of natural origin, plants' and animal world, to study natural processes in biosphere and control modifications of its status. The Law sets out the regime of protection of SPNA within specific boundaries, bans any activities that are disruptive thereto. It contains provisions on liability for failure to comply with protective measures established in respect of SPNA. Several categories of SPNAs are

distinguished depending on protective regime and managing organization status (zapovedniks, national parks and natural parks, zakazniks, nature monuments and other). The Law contains no provisions on wetlands (including water areas) of international importance with the specific status suggesting special protection pursuant to the Ramsar Convention.

High priority areas are:

- zones that are ecologically vulnerable to oil pollution impact when exposed to long-term negative effects of oil;
- zones of recreation and/or high aggregations of people where pollution is to bring about serious modification in the living standards of the population;
- industrial zones and infrastructure where pollution is to cause significant disruption in normal functioning of infrastructure;
- water protection zones of water courses, shore protective belts;
- water courses of high importance for fisheries;
- districts and zones of sanitary protection of water courses used as sources of fresh water, water supply for household, industrial as well as treatment purposes;
- protective forests and special protective forest sites;
- traditional use areas and archaeological monuments;
- habitats critical for species;
- fisheries basins and water course of importance for fisheries, fish protection and strict protection fisheries zones;
- other areas subject to approval by authorities.

Federal Law of April 24, 1995 No. 52-FZ *"On animal world"* establishes requirements related to the protection of objects of animal world and their habitats. Any activity affecting habitats shall be carried out in accordance with the provisions of this Law. Apart from establishing special areas to protect habitats of rare species protective zones of land and water of local significance are designated. Bans or restrictions on human activity within such zones are introduced. Actions with potential to cause extinction or reduction of populations or habitats of rare species are prohibited. The Law lays down provisions on liability for violation of rules related to use and protection of animals.

Federal Law of June 25, 2002 No. 73-FZ *"On objects of cultural heritage (historic and cultural monuments) of the peoples of the Russian Federation"* stipulates for establishing, protection and use of the objects of cultural heritage.

Federal Law of February 23, 1995 No. 26-FZ *"On health rehabilitation areas and health resorts"* establishes the regime of such SPNA type as health rehabilitation areas and health resorts, as well as sanitary (mountain-sanitary) protection districts.

Water Code of the Russian Federation of June 3, 2006 No. 74-FZ provides for water protection zones of water courses and shore protective belts.

Forest Code of the Russian Federation of December 4, 2006 No. 200-FZ provides for establishing of protective forests and special protective forest sites.

Federal Law of December 20, 2004 No. 166-FZ *"On fisheries and protection of aquatic biological resources"* provides for fish protection and strict protection fisheries zones.

Above mentioned acts of legislation present instruments of *immediate* relevance for the development of environmental vulnerability maps. However, to get an idea of general framework of Russian legislation on nature protection and related aspects some *other documents* of certain degree of relevance shall be mentioned.

1.2. Documents related to the development of vulnerability maps

Russian legislation on protection of nature comprises the corpus of legal acts regulating relations within society as far as its interactions with nature are concerned to provide for favorable status of natural environment. Acts of legislation and other normative acts on conservation are meant to provide for the right of people for favorable environment. They aim at prevention of harmful effects of any activities on natural environment and establishing rational use of natural resources, preservation of the balance in nature for the sake of the present and future generations.

The Russian conservation legislation and regulative framework includes the following components:

- The Constitution of the Russian Federation;
- International instruments (agreements, conventions and other sources of international law) that Russia is a party to (including participation through the continuation of obligations of the USSR);
- Russian Codes and Federal Laws;
- Decrees of the President of the Russian Federation, Resolutions (Orders) of the Government of the Russian Federation, acts of other executive authorities (ministries, services, agencies, committees);
- Laws of the subjects of the Russian Federation;
- Acts of executive authorities of the subjects of the Russian Federation;
- Regulative framework established by state standards (GOSTs) and construction norms and rules (SNiPs);
- Sectorial and interdepartmental scientific and technical documents.

The Constitution of the Russian Federation of December 12, 1993 lays down the general principles of legislation on use of natural resources and protection of environment (Articles 9, 41, 42, 58, 71, 72, 74, 114). It guarantees everyone's right to a favorable environment and reliable information about its condition. By the Constitution, the joint jurisdiction of the Russian Federation and the subjects of the Russian Federation includes the use of natural resources, protection of environment and safety for the population. Any laws and regulations adopted on the federal level are applicable throughout all and any administrative units and, as far as possible, take into account interests of local communities.

The Russian Federation by acts of legislation has ratified a number of international conventions most of which contain provisions on environmental protection (the purpose of these conventions in the majority of cases is reflected in their titles). The background of environmental cooperation on activities most frequently exercised on the shore and in water areas of the Russian seas is provided by the following international instruments:

Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar, 2 February 1971; ratified by the USSR in 1976). The Convention aims at conservation and protection of wetlands that are habitats of migrating waterfowl.

UN Declaration on environment and development (Rio de Janeiro, 14 June 1992) proclaims 27 principles of environmental protection and development. The cornerstone is Principle 1 stating that "Human beings are at the center of concerns for sustainable development". Other 26 Principles postulate objectives of nation states that being reached will provide for the implementation of Principle 1. This document is perceived in Russia as a declaration establishing general principles and norms of international law.

Convention on Biological Diversity (Rio de Janeiro, Brasilia (adopted in 1992; ratified by the Russian Federation in 1994; in force from 4 July 1995). The Convention aims at the conservation of biological diversity and the sustainable use of its components.

Convention Concerning the Protection of the World Cultural and Natural Heritage (Paris, 16 November 1972; ratified by the Decree of the Presidium of the Supreme Soviet of the USSR 9 March 1988). The Convention provides for safeguarding of unique natural formations, demonstrate the importance of areas, fosters tourism in, monitoring of and control over preservation of integrity of natural formations.

Charter of Economic Rights and Duties of States (adopted 12 December 1974 by the UN General Assembly).

Convention on the conservation of European wildlife and natural habitats, signed in Bern (Switzerland) in 1979. The aims of this pan-European Convention are "to conserve wild flora and fauna and their natural habitats, especially those species and habitats whose conservation requires the co-operation of several States, and to promote such co-operation". The Convention contains provisions on protection of both habitats and flora and fauna species that a subject to protection.

The Ocean Charter (ratified by the Decision of the Russian Federation 4 January 1999 No. 13 "On accession of the Russian Federation to the Ocean Charter".

Convention on the Territorial Sea and the Contiguous Zone (ratified by the Presidium of the Supreme Soviet of the USSR on 20 October 1960).

Convention on the High Seas (Geneva, 29 April 1958). Ratified on 22 November 1960. Entered into force on 30 September 1962.

Convention on the Continental Shelf (Geneva, 29 April 1958). Entered into force on 10 June 1964.

United Nations Convention on the Law of the Sea 1982 (ratified by Federal Law of February 26, 1997 No. 30-FZ, effective for the Russian Federation from April 11, 1997).

Pan-European Biological and Landscape Diversity Strategy (Sofia, 25 October 1995, signed by the Russian Federation in October 1995).

Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (Moscow-Washington-London-Mexico, 29 December 1972) is based on the recognition of the fact that the capacity of the sea to assimilate wastes and render them harmless, and its ability to regenerate natural resources, is not unlimited. It specifies the substances prohibited from dumping and the substances not to be dumped unless special permission is obtained through special procedure.

International Convention for the Prevention of Pollution from Ships (MARPOL) (London, 2 November 1973), bulletin No. 1 amending and modifying MARPOL-73/78 and resolutions of IMO Committee on protection of marine environment from pollution from ships. By the Convention the Parties to it recognize that any

deliberate, negligent or accidental release of oil and other harmful substances from ships constitutes a serious source of pollution.

International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (Brussels, 29 November 1969). Entered into force on 6 May 1975. By the Convention a Party thereto has the right to take such measures on the high seas as may be necessary to prevent, mitigate or eliminate danger to its coastline or related interests from pollution by oil or the threat thereof, following upon a maritime casualty or acts, which may reasonably be expected to result in major harmful consequences. Any Party which has taken measures in contravention of the provisions of the Convention causing damage to others, shall be obliged to pay compensation to the extent of the damage caused by measures which exceed those reasonably needed.

International Convention on Oil Pollution Preparedness, Response and Co-operation, (London, 30 November 1990). By the Convention Parties thereto recognize the need for international cooperation and strengthening of the existing national, regional and global preparedness for oil pollution and response capacity.

Law of the Russian Federation of February 21, 1992 No. 2395-I *"On subsoil"* regulates relations on geological survey, use and protection of subsoil within the territory of the Russian Federation. The competence of organs of state power according to this Law covers exercise of jurisdiction in respect of subsoil of the Russian continental shelf (Articles 3 and 6). By virtue of Article 22 of this Law, compliance with adopted standards (norms, regulations) on protection of subsoil, ambient air, land, forest and water is one of the key obligations of subsoil user.

Federal Law of November 30, 1995 No. 187-FZ *"On the continental shelf of the Russian Federation"* defines the status of the continental shelf of the Russian Federation, the sovereign rights and jurisdiction of the Russian Federation over its continental shelf and their exercise in accordance with the Constitution of the Russian Federation, the generally recognized principles and rules of international law and the international treaties of the Russian Federation. The Russian Federation exercises over the continental shelf jurisdiction with respect to marine scientific research, protection and conservation of the marine environment in connection with the exploration and exploitation of the continental shelf, its mineral and living biological resources, the dumping of wastes and other materials, the laying and use of submarine cables and pipelines of the Russian Federation (Article 5).

Licenses for the geological survey of the continental shelf and the prospecting, exploration and exploitation of mineral resources is issued by the federal authority responsible for the management of the state subsoil fund subject to approval by other federal executive authorities (Article 8). Strict nature reserves, closed and reserved zones and other specially protected areas of the continental shelf of particular importance for the conservation, reproduction and migration of valuable species of living resources shall not be included in licenses.

License holders must take measures, observe international norms and standards, laws and regulations of the Russian Federation on protection of marine environment and aquatic biological resources, present documents as requested by competent authorities.

Federal Law of December 17, 1998 No. 191-FZ *"On the exclusive economic zone of the Russian Federation"* defines Russian exclusive economic zone as a maritime area beyond and adjacent to the territorial sea of the Russian Federation with a specific legal regime established by this Law, the international treaties to which the Russian Federation is a party and the norms of international law. By Article 16 of this Law the

issues related to regional geological survey, geological survey, prospecting and use of mineral resources are governed by provisions of Federal Laws "On the continental shelf of the Russian Federation" and "On production sharing agreements" and Law of the Russian Federation "On the continental shelf of the Russian Federation".

Pollution of the marine environment in the sense of the Law is the introduction by man, directly or indirectly, of substances or energy into the marine environment which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and worsening conditions for recreation. Federal organs of power provide for the state environmental assessment, control and monitoring of the condition of the exclusive economic zone with the participation of executive bodies of the subjects of the Russian Federation whose territories are adjacent to the shore.

Federal Law of July 7, 1998 No. 155-FZ *"On the internal maritime waters, territorial sea and contiguous zone of the Russian Federation"* defines status and legal regime of water areas specified in its title. By the Law, the principles for economic relations in respect of use of natural resources are as follows:

- payment for the use;
- liability for violating the conditions of economic activities;
- compensation for damage caused to waters, natural resources, environment, historic and cultural monuments;
- financial security for measures related to the restoration and protection of the above mentioned objects.

Land Code of the Russian Federation of October 25, 2001 No. 136-FZ is the basic document defining the use and protection of land. Provisions on use of specific types of land (Article 87) and areas where special conditions of use apply are also prescribed by:

- the Government of the Russian Federation in respect of land owned by the Russian Federation;
- executive bodies of the subjects of the Russian Federation in respect of land owned by relevant subjects;
- local self-government bodies in respect of lands owned by relevant municipalities.

Water Code of the Russian Federation of June 3, 2006 No. 74-FZ regulates the use and protection of water resources, impact on water courses. Use of water courses shall not produce negative impact on environment. It is prohibited to commission facilities designed for the transport and storage of oil and (or) oil products without outfitting such facilities with devices preventing the contamination of water courses. In order to ensure the efficient use and protection of water courses, basin councils are established to develop recommendations regarding the use and protection of water courses within the boundaries of basin districts. Standards of permissible impact on water courses are introduced to keep water quality on the level prescribed by legislation. Such standards are subject to approval by the Government of the Russian Federation. It is prohibited *inter alia* to discharge drainage water to the following water courses:

- designated as specially protected;
- fisheries protection zones and strict protection fisheries zones.

To protect the original environment and traditional trade activities of small-numbered indigenous peoples of the North, Siberia and the Far East of the Russian Federation executive organs of the subjects of the Russian Federation establish special rules for the use of water courses in areas of habitation and traditional life-style of these peoples.

Basic conditions of the use of water courses (Article 42) include requirements to design and timely implement measures of protection of water courses, aquatic biological resources, fauna and flora. . Water protection zones (Article 65) present the territories adjacent to the shoreline of seas, rivers and streams where special conditions of human activities are introduced to prevent contamination, littering, silting and depletion of water courses, preserve habitats of aquatic biological resources and other objects of flora and fauna. Near-shore protective belts are designated within water protection zones where additional restrictions on human activities apply. The width of water protection zones for seas, rivers and streams as well as the width of their near-shore protective belts are measured from the corresponding shoreline. Any activities on water courses or within water protection zones thereof are subject to prior approval by competent authorities.

Forest Code of the Russian Federation lays down the legal basis for protection, reproduction and rational use of forests in the Russian Federation.

Federal Law of May 7, 2001 No. 49 FZ *"On areas of traditional nature use by small-numbered indigenous peoples of the North, Siberia and the Far East of the Russian Federation"* provides for protection of land within areas where small-numbered peoples exercise traditional nature use.

Federal Law of April 30, 1999 *"On guarantees of the rights of the indigenous small-numbered peoples of the Russian Federation"* supplements the provisions of Article 69 of the Constitution of the Russian Federation and is the key legal act on rights of the indigenous peoples. According to this Law the indigenous peoples and unions thereof to protect their original environment, traditional life-style, trade and crafts are entitled to:

- own and use lands of different categories and mineral resources free of charge according to regulations prescribed by the federal legislation and legislation of the subjects of the Russian Federation;
- participate in exercise of control over land use and compliance with relevant environmental laws;
- receive the funds needed for the development and protection of environment, traditional life-style, trade and crafts;
- participate in preparation of and making decisions on protection of environment, traditional life-style, trade and crafts.

Federal Law "On industrial and consumer waste" defines requirements to handling of waste, liability and training of personnel, waste ownership rules.

Federal Law "On Environmental Impact Assessment" defines objectives of the State Environmental Impact Assessment (EIA) as testing compliance of planned activity with environmental requirements and establishing admissibility of such an activity. Numerous regulations have been adopted pursuant to the Law to further its provisions. The adoption of this Law provided legal grounds for the transition from liquidation of negative impact of commercial activities to prevention of such impacts at early stages of the decision making process.

Liability for violation of environmental legislation. The majority of sources of environmental law establish different types of liability for violation of rules of nature use and environmental protection. As a rule sources of environmental law establish

general provisions on liability whereas its scope is defined by other normative acts of the Russian Law. Criminal, administrative and civil liability are distinguished as separate categories. Criminal Code of the Russian Federation contains Chapter 26 devoted to environmental crime. The Chapter consists of 17 articles on crimes regarded as environmental (Articles 246 – 262). Code of Administrative Offenses of the Russian Federation devotes to environmental offenses Chapter 8. Civil liability arises in cases when failure to comply with applicable norms and rules causes damage to natural environment, companies, institutions, organizations and people. Both natural and legal persons are subjects to liability. By Civil Code of the Russian Federation the damage must be indemnified by the guilty party in full (Article 1064).

Requirements of sources of international law related to environmental protection and nature use. The key element of Russian legislation in this respect is paragraph 4 of Article 15 of the Constitution of the Russian Federation defining that generally recognized principles and norms of international law and the international treaties of the Russian Federation are a constituent part of its legal system and take precedence over those stipulated by national law.

Special legislation related to the protection of sea shorelines in the Russian Federation is missing. From the Soviet times, however, use of coastal areas has been legally defined by a number of acts and it holds good so far. The protection of sea shorelines is based on provisions of such sources of Russian Law as Water Code, Land Code, Forest Code and other acts of legislation.

International conventions adopted by the international community are also of relevance for the protection of environment and natural resources *inter alia* in coastal zone of Russia. Russia has ratified most of them and is implementing the same. The most relevant instruments are mentioned above. One of the cornerstones of protection of environment (including shorelines) is the Decree of the President of the Russian Federation (1996) «On transition to the sustainable development» adopted in furtherance of the basic documents adopted by the UN Conference on environment and development (Rio de Janeiro, 1992). The Decree of the President of the Russian Federation "On measures of protection of marine biological resources and state control to this end" (1997) was of great importance, too.

The role of above mentioned laws of the Russian Federation in protection of shorelines is of significance as well. Their implementation was fostered by adoption of resolutions of the Government of the Russian Federation whose provisions were further developed through adoption of a series of legal acts by the federal and regional authorities. Their importance stems from the fact that all laws, including environmental ones, just provide a most general framework for practical implementation of legal and economic mechanisms of protection of environment and rational use of nature. Laws cannot function without implementation instruments stipulated in by-laws. The following resolutions of the Government of the Russian Federation are important from environmental perspective:

- No. 158 of February 19, 1996 «On the Red Book of the Russian Federation»;
- No. 801 of December 25, 2006 «On adoption of Regulation on state control and supervision of the use and protection of water courses»;
- No. 90 of January 26, 1998 «On implementation of the Decree of the President of the Russian Federation on enforcement of protection in respect of marine biological resources and state control to this end». The latter Resolution vests the Russian Federal Border Service with the authority to ensure compliance with the Russian Law and implementation of international agreements related to protection of aquatic biological resources.

Guidelines, rules and resolutions adopted by competent bodies of different level are also applicable to the protection of nature in coastal zones. Marine coastal zone in particular (according to Article 16 of Water Code of the Russian Federation 1995) is regarded as water protection zone. Accordingly, activities are restricted within this zone (pursuant to Article 65 of Water Code of the Russian Federation).

In accordance with «SanPiN 2.1.5.2582-10. Sanitary and epidemiological requirements to the protection of sea waters near the shore from pollution at sites of public water use. Sanitary and epidemiological rules and norms» the protective land strip adjacent to protected marine areas is established. The limit of such land strip on land is established at 2 km distance from the line of maximum tide. The buffer zone of 2 km is established to protect waters from pollution, provide for the safe public use for recreation, treatment and rehabilitation, household purposes and aquaculture. Facilities located or to be located within 2 km buffer zone shall be designed in a mode preventing pollution.

The rules of reporting on pollution of the sea are prescribed by the guidelines of the Russian Ministry of environment and natural resources of May 12, 1994. The substance of the guidelines reflects the nature of obligations of the Russian Federation from international conventions MARPOL, Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (see above) and other international instruments.

APPENDIX 2.

Characteristics of oil

Table 2.1. Description of characteristics of oil in sea water

	Light (ρ < 0.878 g/cm³)	Heavy (ρ varies from 0.878 to 0.884 g/cm³)	Very heavy (ρ > 0.84 g/cm³)
Open water			
Spreading	Very fast, 1 t in 10 minutes develops into slick 50 m in diameter with medium thickness of 0.1 mm	Fast, 1 t in 10 minutes develops into slick 20 m in diameter	Slow, 1 t develops into slick not exceeding 10 m in diameter
Evaporation	Up to 100%	Up to 40%	Not exceeding 10%
Dissolution	100–1000 mg/l	3–30 mg/l	Up to 0.001 mg/l
Dispersion	No dispersion due to fast evaporation	Formation of 'oil in water' emulsion primarily	Formation of 'water in oil' emulsion primarily
Sedimentation	No sedimentation due to fast evaporation	Depends on the presence of suspended particles in water Interacts with suspended particles easily	Depends on the presence of suspended particles in water Interacts with suspended particles easily
Sinking	No sinking due to fast evaporation	Insignificant volumes if active sedimentation is present	Right after the spill especially at low temperature in environment
Oxidation	No oxidation due to fast evaporation	The slowest process, does not exceed 0.1% per day, depends on solar radiation	The slowest process, does not exceed 0.1% per day, depends on solar radiation
Aggregation	No sinking due to fast evaporation	Practically missing	Insignificant amount Depends on the volume of oil spill
Coastal zone			
Spreading	Drifts fast forming narrow strip	Drifts along the shoreline following its contour and stranded with waves	Drifts slowly along the shoreline as homogeneous slick
Evaporation	Up to 100%	Up to 40%	Not exceeding 10%
Percolation in soil	Fast Depends on the volume of pollution The bigger mineral particles the deeper penetration	Depends on size of mineral particles, physical volume of pollution may increase when oil mixes with hard particles	Insignificant, produces homogeneous coverage of shore surface

	Light (ρ < 0.878 g/cm³)	Heavy (ρ varies from 0.878 to 0.884 g/cm³)	Very heavy (ρ > 0.84 g/cm³)
Sedimentation	No sedimentation due to fast evaporation	Easily interacts with particles, especially fine particles, and results in increase of physical volume of pollution	Easily interacts with particles, especially fine particles, and results in increase of physical volume of pollution
Oxidation	No oxidation due to fast evaporation	The slowest process, does not exceed 0.1% per day, depends on solar radiation	The slowest process, does not exceed 0.1% per day, depends on solar radiation
In ice conditions			
Spreading	Depends on ice density Slows down	Depends on ice density Slows down	Depends on ice density Slows down
Evaporation	Slows down	Slows down by 50%	Slows down
Dissolution	Slows down significantly	Practically stops	Practically stops
Dispersion	Slows down significantly	Practically stops	Practically stops
Sedimentation	Practically missing	Depends on the presence of suspended particles in water	Depends on the presence of suspended particles in water
Sinking	Practically missing	Increases	Right after the spill especially at low temperature in environment
Oxidation	Practically stops	Practically stops	Practically stops
Aggregation	Practically missing	Practically missing	Increases

Table 2.2 Behavior of different oil types in sea water

Type of oil	Characteristics of oil			
	Evaporation	*Ability to float*	*Dissolution*	*Submersion*
Light	fast	good	good	no
Medium	low	good	low	depending on circumstances
Heavy	no	no	practically missing	sinks

It is recommended to refer to the Rules of application of dispersants in oil spill clean-up (Semanov, 2005) describing behavior of oil in water (see Appendix 2.3)

APPENDIX 2.3

BEHAVIOR OF OIL ON SEA SURFACE

B.1 Spreading

The speed at which spreading takes place depends upon the viscosity of the oil, its density and pour point. Fluid, low viscosity oils, e.g. diesel oil and kerosene, as well as the most Russian crude oils, spread very quickly whereas black strap and waxy crude spread slowly. Spreading stops after several hours or several days after the spill. The oil slicks demonstrates different thickness and color. Bright color slicks (up to 0.01 mm) occupy up to 90% of the slick whereas black spots (thick parts of the slick over 1 mm) normally make about 10% of the slick.

B.1 Drift of oil slick

The oil slick drifts changing its shape on sea surface under the influence of wind and currents. The rate at which the oil spreads is also determined by the prevailing conditions such as temperature, water currents, tidal streams and wind speeds. It is generally accepted that the speed of drift of the slick is 3% of the wind speed. The drift speed of submerged oil at depth up to 2 m drops to 1% of the wind speed. The oil slick transforms taking the shape of oval with tails and may fall apart into several smaller slicks under the influence of wind and wave action.

B.2 Evaporation

Transition of lighter components of the oil to the atmosphere through evaporation is one of major natural factors facilitation removal of oil from sea surface. The speed of evaporation depends on pressure of oil gases, wind speed and, to a lesser degree, from the temperature in the environment. Those components of the oil with a boiling point under 200°C (gasoline fraction) tend to evaporate within several hours, and those with a boiling point up to 270°C evaporate in several days. Evaporation increases the viscosity of the remaining oil, its pour and flash points.

B.3 Dissolution

Dissolution of oil and oil products in water is usually insignificant. It is noteworthy that it is light aromatic hydrocarbons that tend to dissolve and they constitute the most toxic fraction.

B.4 Photooxidation and biodegradation

Polar components of oil are oxidized under the influence of ultraviolet radiated by the sun. This increases the ability of the oil to dissolve and promotes for stabilization of water emulsion in the oil.

Microorganisms that are capable of metabolizing oil through using it as source of food and energy are always present in the sea. In case of oil spill their concentration increases rapidly. It is the paraffin fractions of oil that are apt to be degraded (n-alkanes). The rate of biodegradation depends on the presence of oxygen and nutrients (nitrate and phosphorus). It is insignificant and photo- and biooxidation removes only few percent of the oil spill.

B.5 Sedimentation, sinking of oil

Oil reaches the bottom of the sea by several ways:

- residues of crude oil as the result of weathering processes may obtain the density higher than that of the sea water;
- oil sticks to sand, suspended particles and sinks to the bottom.

B.6 Natural emulsification of oil

Under the influence of waves and currents oil on the surface of water may undergo emulsification developing emulsions of two types: 'direct' oil in water and 'inverse' water in oil emulsions.

Oil-in-water emulsion is formed by wave action breaking oil slicks into droplets and transferring them into the water column of the sea. The size of oil droplets formed in this case varies from 0.001 to 1 mm. Large droplets of 0.1 mm and bigger in absence of wave action rise to the surface and stick together forming oil slick again. Smaller droplets rise slowly or, in the absence of currents, concentrate at the face of water and oil film and gravitate to the water column under the influence of waves and currents. This type of oil emulsification produces manifold increase in the surface of oil exposed to the contact with water and facilitates chemical and biochemical degradation. Therefore oil is easily destroyed by natural factors within a few days. It is believed that the wave action of up to 5 points on the Beaufort scale turns from 0.5 to 2% of the oil by volume to oil-in-water emulsion per hour during the first 10 hours after the spill, then the process slows down and stops after a few days.

Inverse emulsion is formed by the penetration of water into the oil film. Formation of inverse emulsion is accompanied by the increase in viscosity and density of the oil slick leading to manifold growth of the oil slick volume. This process goes faster when light fractions evaporate and the remaining fractions are oxidized. Formation of inverse emulsion slows down and, subsequently, prevents natural degradation of oil and its dispersion in water column in the form of oil-in-water emulsion. Inverse emulsions remaining afloat on the surface gain stability turning with time into ‘chocolate mousse’ and ‘tar balls’. The latter may persist in natural environments for years.

Practically the whole volume of some heavy oils with viscosity over 50000 cSt, as well as, e.g. ‘Orimulsol’, turns into ‘chocolate mousse’ without dispersing in the sea whereas staying afloat poisoning environment for a long time.

APPENDIX 3.

The vulnerability of shorelines to spills of oil and oil products

Forecasting fate of oil on shore takes knowledge of certain peculiarities of shorelines. They include:

- litho-dynamics peculiarities of the shoreline (inflow, transport and accumulation of sediments);
- relative exposure to wave and tidal energy;
- details of profile and morphometrics of shorelines;
- the degree of indentation of the shoreline, that is the presence of natural geomorphological 'pockets' for oil;
- parameters of the rock establishing massif the shoreline is built upon;
- lithological parameters of sediments on the shore;
- the presence of submerged vegetation and the degree of projective coverage of the bottom.

Table 3.1 Examples of the 10 levels of the Environmental Sensitivity Index (IMO/IPIECA, 2012)

Index 1

1A *Exposed rocky shore*
1B *Exposed, solid man-made structures*
1C *Exposed rocky cliffs with boulder talus base*

Index 2

2A *Exposed wave-cut platforms in bedrock, mud, or clay*
2B *Exposed scarps and steep slopes in clay*

Index 3

3A *Fine- to medium-grained sand beaches*
3B *Scarps and steep slopes in sand*

Index 4

Coarse grained sand beaches

Index 5

Mixed sand and gravel beaches

Index 6

6A *Gravel beaches (granules and pebbles)*
6B *Riprap structures and gravel beaches (cobbles and boulders)*

Index 9

9A *Sheltered tidal flats*
9B *Vegetated low banks*
9C *Hypersaline tidal flats*

Index 10

10A *Salt and brackish water marshes*
10B *Freshwater marshes*
10C *Swamps*
10D *Mangroves*
10E *Inundated low-lying tundra*

Table 3.2 Examples of the 10 levels of the Environmental Sensitivity Index (IMO/IPIECA, 2012, with amendments)

ESI	Shoreline type	Typical features of shorelines	Fate of oil and cleanup peculiarities
1A	Exposed abrasion shore composed of solid rock	• Wave-cut terrace is composed of solid bedrock, outcrops and sediments. An impermeable substrate is formed.	• Oil slick is held back by the action of the reflected waves • Oil often persists on dry and coarse surface of a structure and it is not the case with wet surfaces • Oil is more persistent when it forms a line above the level of high tide • The substrate is impermeable and oil therefore persists on the surface and is removed thereof in the course of natural processes in few weeks following its accumulation. • Normally no cleanup is required. High-pressure water spraying may be used to remove oil from cracks and caverns.
1B	Man-made structures	• Engineered structures composed of seawalls, breakwaters, piers, etc. • There is often substrate unsuitable for biota (tetrapods), however in some cases inhabitants are abundant. • Erected to protect shorelines from action of waves, including vessel induced. Impacted by the processes with relatively high energy. • The biota attached to structures is sparse or demonstrate moderate abundance.	
2	Exposed wave-cut platforms in bedrock or dense clayish sediments	• Found along swampy shoreline exposed to wave action. As the platform advances the zone exposed to wave action remains behind on the former mud flats. Beaches (made of sand or larger particles) are often formed at the head of mud flats. • Platforms are composed of dense clay with inclusions of peat. • Width of platforms can vary from one meter to few dozen meters. • Species abundance and diversity are low.	• Oil does not persist on wet surface of clayish sediments yet may penetrate through channels. • The presence of oil slick is short term except for the cases when the oil is present in pools where surface subsided. • Oil is normally quickly removed from platforms through natural wave action. • No cleanup is normally required except for the sites where intensive fishing activities take place.
3	Accumulative shelving shoreline with fine- to medium-grained sand beaches	• Beach has gentle or steeper slope composed mostly of fine sand, primarily silica sand. • Infauna species are relatively sparse, algae communities may be present. It is actively used by animals (birds and marine mammals, etc.). • Beach areas as a rule are actively used for recreation.	• Light oil forms a band along high-tide swash line, heavy oil accumulations will cover entire beach face. • Maximum percolation of the oil into sediments of the beach will be 10-15 cm. • Oiled sediments may be buried after accumulation on the beach to 30 cm in the course of first few weeks after the oil spill. • Organisms inhabiting beach sediments may die of oxygen shortage or lethal concentrations of oil in interstitial water.
4	Accumulative shoreline with coarse-grained sand beaches	• Beaches demonstrate moderately steep slope and varied width. They are composed of coarse sediments. • Diversity and density of species are lower than in the beaches of fine sand.	• In case of a minor spill the oil will be accumulated as a band along high-tide swash line, in case of significant oil spill the impact zone may comprise entire beach face. • The depth of penetration of oil into sediments of the beach may be 25 cm. • Oiled sediments may be buried to 60 cm and deeper in the course of one tidal cycle. • The impact on biota may be expressed in temporary reduction of abundance of infauna species thus affecting the quality of habitats of birds. • Cleanup should be effected with care to prevent grinding oil deeper into the beach and avoid increased exposure of shoreline to wave action. • Use of heavy equipment for oil/sand removal may result in the removal of excessive amounts of sand; manual cleanup may be more efficient.

ESI	Shoreline type	Typical features of shorelines	Fate of oil and cleanup peculiarities
5	Accumulative shoreline with mixed sand and gravel beaches	• The beach demonstrates 8-15° slope. Beach sediments are composed of mixture of sand and gravel. The gravel content is 20-80%. • Occasionally observed in washout areas behind barrier islands.	• In case of a minor spill the oil will be accumulated above high-tide swash line, in case of a significant oil spill the impact zone may comprise entire tidal zone. • Oil percolation into the beach may be 50 cm. • If no cleanup action is taken in certain sheltered areas of the beach then asphalt covered pockets may be formed. Such accumulations may persist for years.
6A	Accumulative shoreline with gravel beaches (granules and pebbles)	• The beach demonstrates steep slope (10-20°).	• The substrate is highly permeable, oil percolation is up to 100 cm • Oil normally penetrates very deep. Oil may persist on coarse surfaces of debris. • High-pressure water spraying can effectively remove oil in first few hours after the spill. • It will be difficult to remove oil later, the use of hot water may be required. • Mechanical removal or substitution of the most polluted blocks may be required.
6B	Отсутствует за счет быстроro испаре-ния	• Manmade structure is composed of riprap or blocks of concrete with the size from gravel to boulders (10 cm to few meters). • The aim is to protect especially valuable parts of the shoreline from destruction. • Attached organisms on exposed surfaces of riprap are sparse.	
7	Exposed tidal flats (mud flats) composed of lithified sediments.	• Present as large mud flats composed of fined sand and small admixture of gravel matter. • The presence of sand in sediments is indicative of high level of exposure to hydrodynamic factors (waves and tides). • Biological productivity may be high due to abundant infauna and, therefore, good forage basis for birds. Typical of tidal areas between barrier islands and open bays.	• Oil does not cover all surface of the sediments, most of the oil will be pushed across the flat to the line of maximum tide, where deposition of oil may occur on a falling tide if oil concentrations are heavy. • Oil does not penetrate the waterlogged fine sediments. • Threat to biological communities may be high, and especially for infauna, which may result in the degradation of forage basis of other animals. • Natural removal of oil by waves and currents may be very efficient. • Cleanup is quite difficult and possible only during low tides. • The use of heavy machinery should be restricted to prevent mixing oil into the sediments.
8	Sheltered abrasion rocky shore with washout ledge in bedrock	• Shoreline is protected from exposure to waves and currents. • Debris may accumulate at the base of washout ledge. • The slope is moderately steep (>15°). • Very high concentration of attached sea algae and organisms is normally observed. • They are typical of areas near mouths of ducts within deltas and bays.	• Oil accumulates permanently due to low hydrodynamic activity. • The most efficient way to remove fresh oil whereas it is in liquid condition is to spray water at moderate pressure.
8A	Sheltered abrasion rocky shore with washout ledge in bedrock		
8B	Sheltered man-made structures		
8C	Sheltered tetrapods		
8D	Sheltered rocky rubble shores		
8E	Peat shorelines		

ESI	Shoreline type	Typical features of shorelines	Fate of oil and cleanup peculiarities
9A	Sheltered tidal flats	• Sheltered tidal mud flats are composed of mostly aleuritic clay with small admixture of sand and gravel. • Typical of sheltered shorelines with low hydrodynamic activity and normally observed at seaward side of marshes. • Algae and macrophytes are often observed and demonstrate rather high density. • Abundant infauna is observed in sediments thus providing good conditions for feeding of birds.	• Oil normally does not persist here yet is pushed across the flat and accumulates at the line of maximum tide. • The deposition of oil may occur on a falling tide if oil concentrations are heavy. • Oil normally does not percolate into the waterlogged fine sediments yet may percolate clayish sediments through cracks and caverns. • Absorption of oil in areas with high concentrations of suspended particles may result in accumulation of oiled sediments on mud flats. • Threat to biological communities may be significant and therefore sorbents and booms need to be used. • Cleanup of the flat surface after oiling is very difficult because of the soft substrate. Spraying water at low pressure and use of sorbents could be useful.
9B	Vegetated low banks	• These areas are flooded time to time and exposed to impact. They are found along the lower edge of shores of ducts in deltas and bays.	• At low tide the impact is insignificant as oil slick forms a band along the foreshore. • As water arrives the oil slick will spread to the vegetation and may destroy it. • Spraying water at low pressure may efficiently remove oil from low banks.
9C	Hypersaline tidal flats		
10A	Salt and brackish water marshes within the sea and brackish water areas (salt and brackish water marshes)	• Width of the marsh can vary widely. Sediments are mostly composed of clay with abundant organic matter. • Biological communities demonstrate diversity and abundance. • Very common behind barrier islands and along the outer shorelines.	• Oil adheres readily to intertidal 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. • Heavy oil normally does not percolate through sediments whereas light oils can penetrate the top few centimeters. • In case of a minor oil spill manual cleanup is preferable; in case of significant oil spill spraying water at low pressure, use of sorbents and vacuum cleaning are required. • Cleanup must be carefully designed so that to prevent loss of vegetation and penetration of oil to the sediments. • Destruction of oiled vegetation may be effected provided other ecosystem components are not exposed to significant risk.
10B	(Biogeneous) shorelines made of low swamp lands with vegetation (fresh water marshes)	• Trees and bushes covering shorelines of this type normally do not exceed 6 m height. Resident flora and fauna demonstrate diversity in terms of variety of species and their abundance. • Sediments are composed of muds with high presence of detritus originating from plants. They are flooded time to time.	• Fate of the oil depends on the position of water line. During high tide the major part of oil accumulates on plants as film. Trees are less impacted than sward. • Percolation through sediments, as a rule, is insignificant. • The oil is removed in the course of washing of organic detritus by water at low pressure accompanied by the use of sorbents and vacuum cleaning. • Penetration of the oil to sediments and disturbing of root systems of plants should be avoided. • In case of a minor oil spill manual cleanup is best. Trees should not be cut.
10C	Swamps		
10D	Coastal vegetation (trees and bushes) (in the original – mangroves)		

Table 3.3 **The vulnerability of shorelines (from cool colors to warm colors indicating increased sensitivity) to spills of oil and oil products (IMO/IPIECA, 2010, with amendments)**

Code	Shoreline type
	1A – exposed abrasion shore composed of solid rock 1B – man-made structures
	2 – exposed wave-cut platforms in bedrock or dense clayish sediments
	3 – accumulative shelving shoreline with fine- to medium-grained sand beaches
	4 – accumulative shoreline with coarse-grained sand beaches
	5 – accumulative shoreline with mixed sand and gravel beaches
	6A – accumulative shoreline with gravel beaches (granules and pebbles) 6B – shoreline with dumped rock structures and gravel (cobbles and boulders) riprap
	7 – exposed tidal flats (mud flats) composed of lithified sediments
	8A – sheltered abrasion rocky shore with washout ledge in bedrock
	8B – sheltered man-made structures
	8C – sheltered tetrapods 8D – sheltered rocky rubble shores 8E – peat shorelines
	9A – sheltered tidal flats 9B – vegetated low banks 9C – hypersaline tidal flats
	10A – salt and brackish water marshes
	10B – freshwater marshes
	10C – swamps
	10D – coastal vegetation (trees and bushes) (in the original – mangroves)

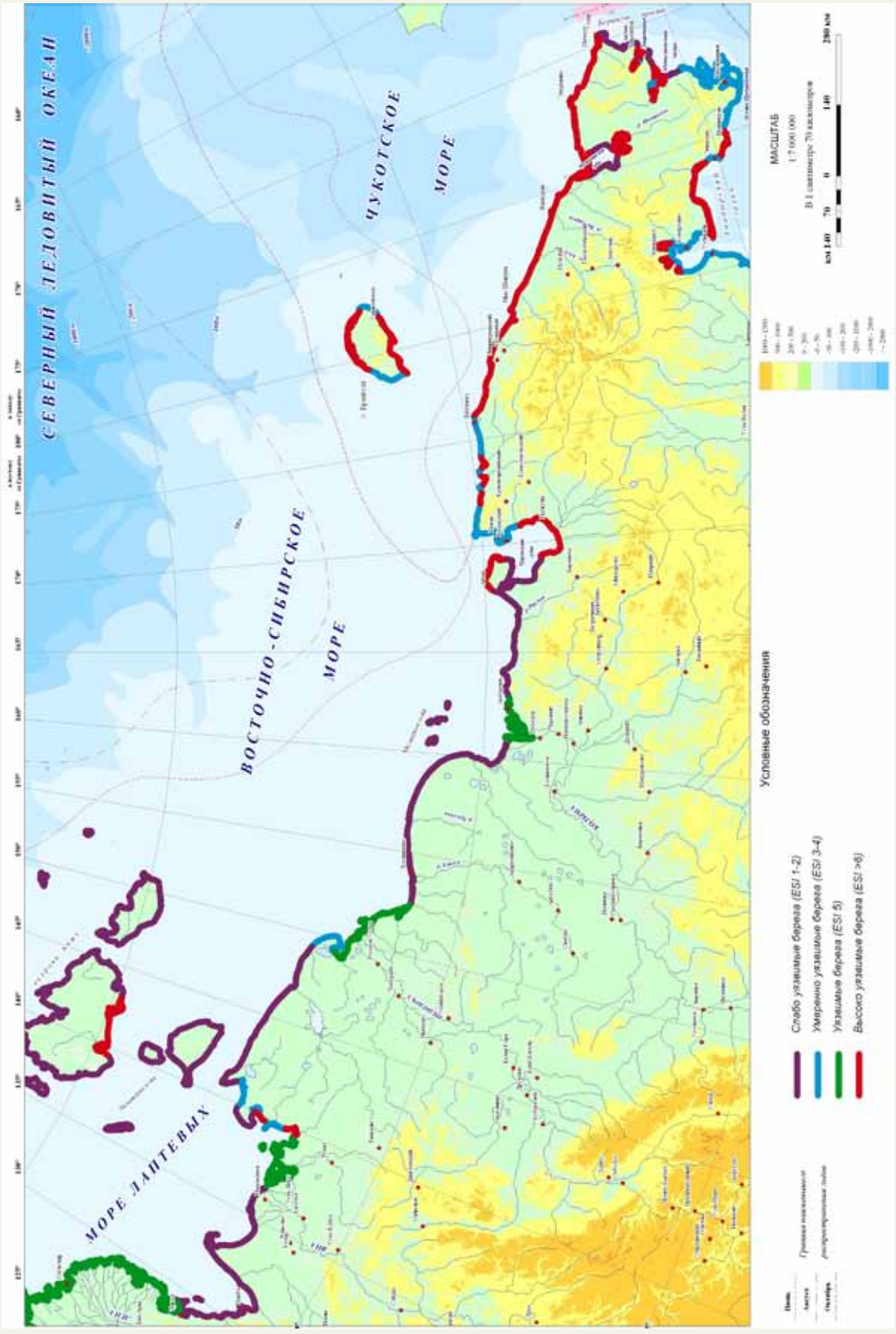


Figure 3.4 Sample ESI-based map of vulnerability of shorelines to oil spills in the Eastern Arctic (2010)

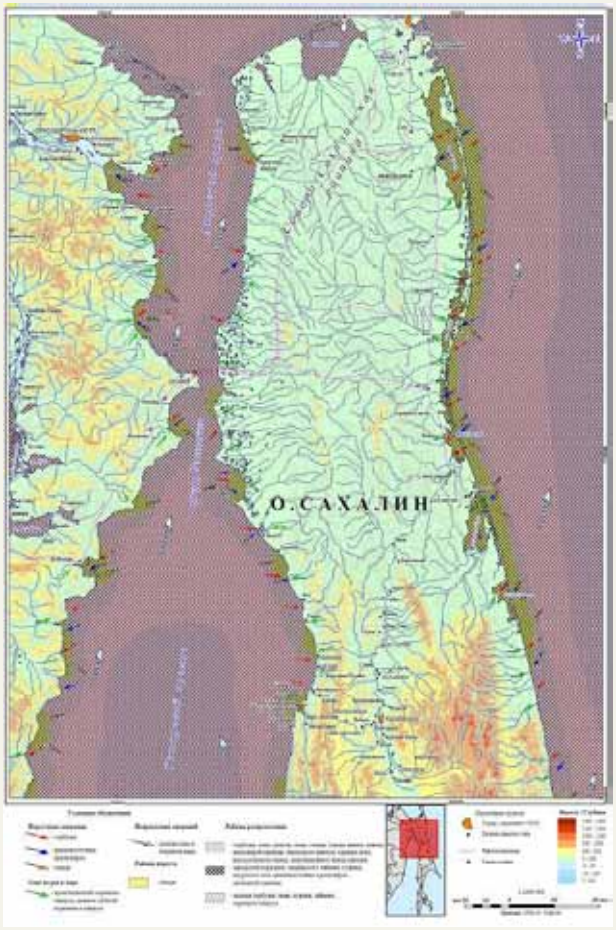
APPENDIX 4.

Sample thematic maps of vulnerability of ecosystem components and priority protection areas of water areas and shorelines against spills of oil and oil products

Figure 4.1 **Season specific ecological vulnerability of 'Sakhalin-1' impact area to oil spills in respect of commercial fish species status (2007)**

A: Spring

B: Summer



C: Autumn

D: Winter

APPENDIX 5.

Supplementary material on testing reliability of data and vulnerability of species and groups of organisms

Table 5.1 Evidence assessment (verification) scale

Whereas the sensitivity of organisms and ability of populations to recover after oil spill are assessed the quality of evidence used varies due to limited volume of special research. The confidence of the evidence used in decision making shall be assessed.

Confidence	Definition (MarLIN, 2001)
1. High	Assessment has been derived from sources that specifically deal with sensitivity and recoverability. Experimental work has been done investigating the effects of factors.
2. Moderate	Assessment has been derived from sources that consider the likely effects of a particular factor.
3. Low	Assessment has been derived from sources that only cover aspects of the biology (ecological peculiarities) of the species or from a general understanding of the species (populations). No information is present regarding the effects of the factor in question.
4. Very low*	Assessment derived by 'informed judgment' where very little information is present at all on the species.
5. Not relevant*	The available information does not support an assessment, the data is deficient, or no relevant information has been found.

* Confidence of data ranked 4 and 5 shall not be considered in the course of decision making

Table 5.2 The scale for ranking vulnerability of species, populations/communities to oil spills on the basis of the sensitivity of organisms and the ability of populations/ communities to recover

		Recoverability*					
		Very low	Low	Medium	High	Very high	Extremely high
		> 25 years or never	> 5-25 years	3-5 years	1-3 years	< 1 year	Weeks
Sensitivity	Extremely high	5	5	4	3	2	1
	Very high	5	4	3	2	1	< 1
	High	4	3	2	1	< 1	
	Medium	3	2	1	< 1		
	Low	2	1	< 1			
	Very low	1	< 1				

Notes: * the ability of the population to recover its abundance depends on the rate of reproduction (reproduction strategy), the population trend and the possibility of migration of individuals from outside areas not affected by the spill

Table 5.3 **Relative vulnerability of components of ecosystems* depending of type of oil and priorities of protection of marine water areas and shorelines** from spills of oil and oil products**

Ecosystem components	Vulnerability coefficient
Ambient air	not relevant
Sea water	not relevant
Bottom sediments	from 1 to «not relevant»
Shoreline (evaluated by ESI scale)	from 1 to 10
Phytoplankton	1
Zooplankton	2
Macroalgae	from 2 to 3
Vascular plants	from 3 to 4
Benthos at depth <10 m	from 3 to 4
Benthos at depth >10 m	from 1 to 3
Larvae in water column and small fry at depth <10 m	from 4 to 5
Larvae in water column and small fry at depth >10 m	from 1 to 3
Larvae on seabed and small fry at depth <10 m	from 3 to 4
Larvae on seabed and small fry at depth >10 m	from 1 to 3
Adult pelagic fish at depth <10 m	from 3 to 4
Adult pelagic fish at depth >10 m	from 1 to 2
Adult pelagic fish at depth <10 m	from 2 to 3
Adult bottom fish at depth >10 m	from 1 to 2
Diving seabirds (*Alcidae*, *Pelecaniformes*)	5
Seaducks and eiders	from 3 to 5
Molting seaducks	5
Other waterfowl	from 1 to 5
Seabirds feeding on surface (*Tubinares*, *Laridae*, *Stercoraridae*, *Sterna*)	from 3 to 5
Shorebirds (*Charadrii*)	from 1 to 3
Birds of prey associated with shore	from 1 to 2
Reptiles and amphibians	from 1 to 3
Cetaceans	from 3 to 4
Pinnipeds	from 4 to 5
Aquatic and semi-aquatic mammal predators	from 3 to 5
Species included into Red Books of the RF or its subjects	from 3 to 5
Protected features	**Priority*** **
Permanent polynyas outside pack ice	from 3 to 5
Habitats of species included into Red Books of the RF or its subjects	from 3 to 5
SPNAs and recreation areas	from 3 to 5
Commercial fisheries grounds	from 3 to 5
Areas of traditional sea based trades of indigenous people	from 4 to 5
Water transport (passages, operation of terminals)	from 1 to 3
Coastal infrastructure features	from 1 to 5
Cultural and historical features (monuments, memorable sites) including archaeological monuments	from 1 to 5

Notes: * '1' — least vulnerable, '5' — most vulnerable', ** '1' — least priority, '5' — top priority, *** All coefficients are corrected by experts in accordance with the principle of regionalization

APPENDIX 6.

Algorithm of mapping integral vulnerability

Stage 1. Establishing of experts working group.

Stage 2. Determining of time limits of seasons in accordance with peculiarities of climate of the area in question.

Stage 3. Deciding on the contents of the set of maps - species/groups of species depending on parameters of marine ecosystem of the area in question and available capacity.

Stage 4. Producing of maps of VECs distribution and areas for priority protection (PPA) Each map is represented as a separate GIS layer. Background maps are presented polygonal shape-files, cells (polygons) are established for ranging of distribution of abundance of selected VECs.

> **4.1.** Season specific thematic maps for each species/group of species are produced, data on distribution of objects (abundance indicators) for each cell of thematic maps are determined. Then season specific data on the presence of an object in the given area or its abundance indicators are entered into the fields of the properties table for each object of a thematic layer. Qualitative parameters are attributed to ranks.
>
> **4.2.** Maps of areas for priority protection are produced, sensitive socio-economic features are mapped.

Stage 5. A separate map of shorelines vulnerability is produced. Auxiliary materials are presented in Appendix 3.

Stage 6. Vulnerability coefficients of VECs and priority for the protection of sensitive socio-economic features are determined. Auxiliary materials are presented in Appendix 5.3.

Stage 7. Integration of maps of VECs with the same vulnerability coefficient.

Stage 8. Data on the distribution of the objects in every cell are multiplied by the vulnerability coefficient attributed to the corresponding group of VECs.

Stage 9. Integration of all independently derived layers of maps of distribution of biota and PPA.

Stage 10. Setting minimum and maximum values of the integral vulnerability. It is advisable to develop maps with reference to the integral vulnerability scale with five ranks from minimum to maximum integral vulnerability. Experts determine the range of ranks. The results are presented as a set of season specific maps (spring, summer, autumn, winter). The integral vulnerability of the area is represented in color coding from red ('very high vulnerability') to green ('low vulnerability') through yellow ('medium vulnerability').

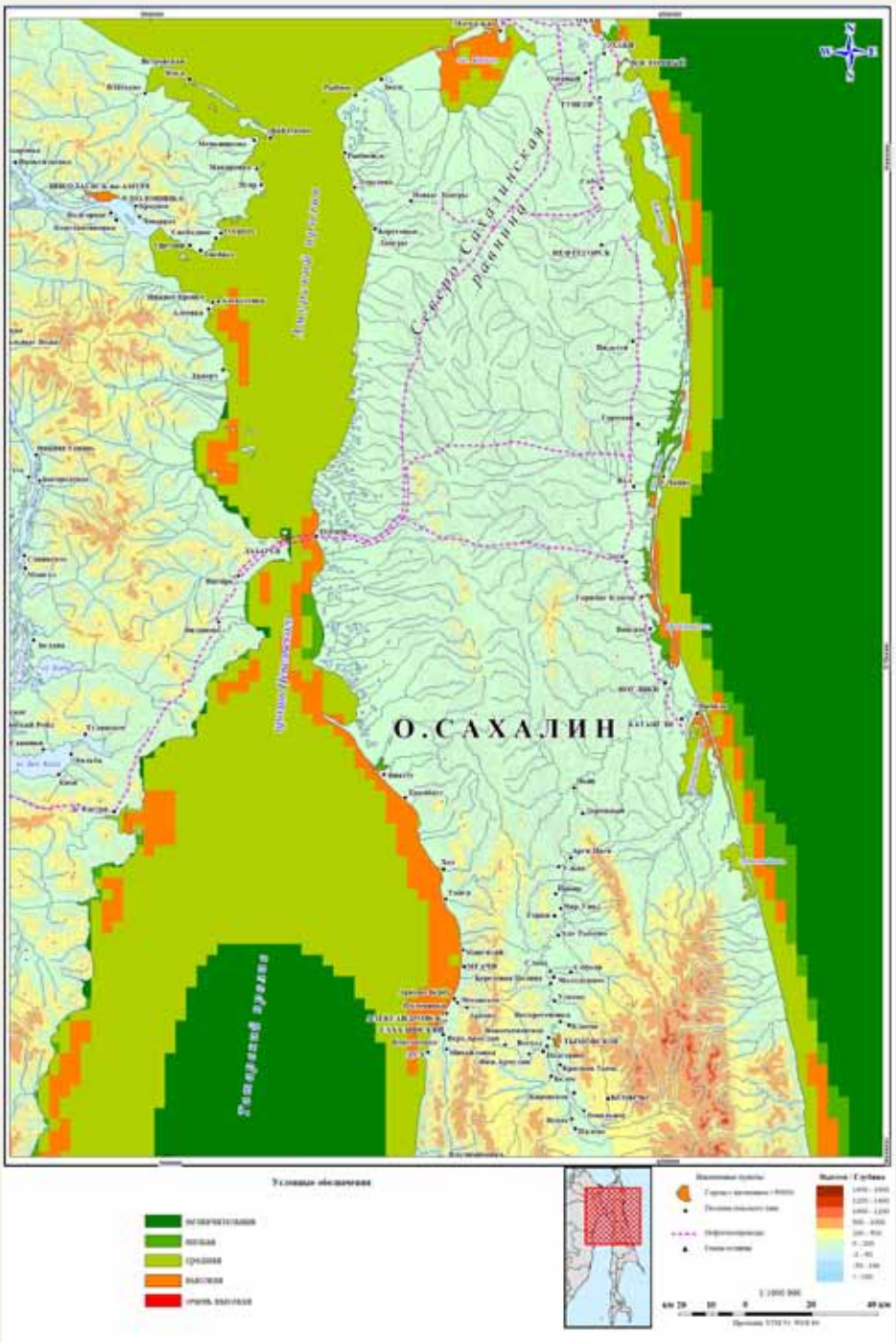
Stage 11. A separate layer reflecting logistical and operational oil spill response features is developed.

Appendix 6.1 Auxiliary flowchart for the development of maps of ecologically vulnerable zones and areas for priority protection

APPENDIX 7.

Sample integral vulnerability maps

Figure 7.1 **The integral vulnerability to oil spills of 'Sakhalin-1' impact area in spring and summer (Pogrebov, 2010b)**



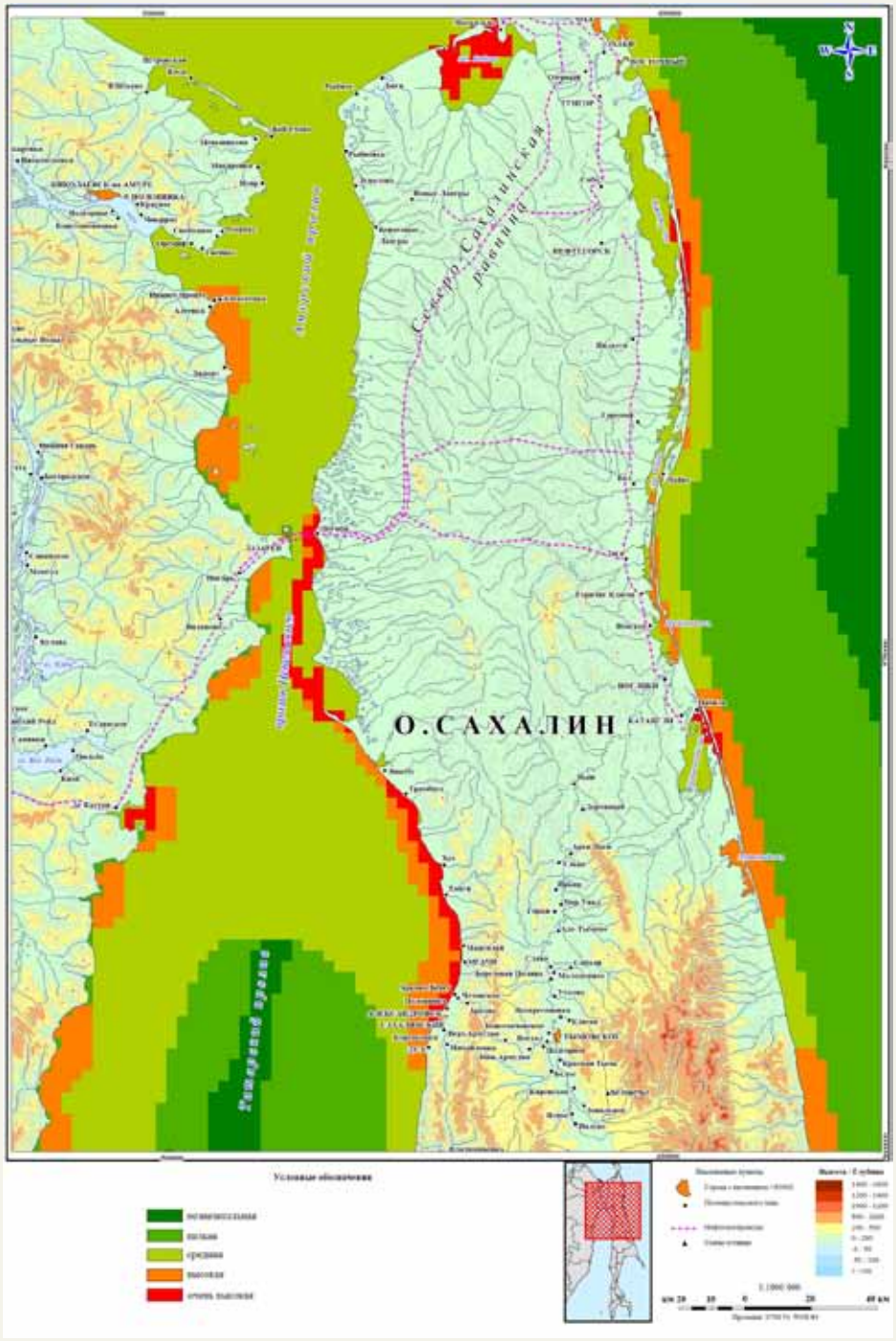

О.САХАЛИН
Северо-Сахалинская равнина
Амурский залив
Залив Анива
Условные обозначения

Figure 7.2 **The integral vulnerability of the seas of the Eastern Arctic to oil spills in May-June (top) and July-August (bottom). (Set of maps, 2010)**