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MAPPING OF ECOLOGICALLY VULNERABLE ZONES AND REGIONS OF WATER AREAS AND SHORELINES WITH PRIORITY PROTECTION AGAINST SPILLS OF OIL AND OIL PRODUCTS IN RUSSIA

ABSTRACT

Map development for ecologically vulnerable zones and regions of water areas and shorelines with priority protection against spills of oil and oil products is important because of (1) the population's concern about the growing technological load on nature, and (2) the need to comply with the existing state legislation. At present there is no general methodology for development of vulnerability maps in Russian Federation. The integral maps to be used in prevention and control of oil spills should represent data about ecological vulnerability to oil of both coastal and water ecosystems and information about legally protected objects, zones and regions. A set of maps showing absolute and relative integral vulnerability of particular water areas allows analyzing spatial-temporal dynamics of this indicator. The most vulnerable parts of the water area could be selected, as well as the most dangerous seasons. Recommendations are elaborated in order to organize the most effective protection of the environment against any possible emergency spills of oil and oil products.

KEY WORDS: ecological vulnerability, nature protection areas, oil spills, mapping, methodological approaches

INTRODUCTION

Map development for ecologically vulnerable zones and regions of water areas and shorelines with priority protection against spills of oil and oil products is important for the modern society for two reasons. The first is population's concern about the rise of technological load on nature, and a will to keep wildlife in its natural (undisturbed) condition, providing for reliable prospective of mankind's development. The second reason, partially conditioned by the first one, is the need to comply with the existing state legislation regarding development of measures to prevent and liquidate spills of oil and oil products. These two reasons determine the list of objects to be shown on general (integral) maps and should determine

decisions for liquidation of oil spills in seas, rivers, lakes and their shorelines.

Until now experts have accumulated knowledge allowing ranging vulnerability of various biological groups of plants and animals to oil spills, specifying periods of time (or seasons) when these plants and animals are most vulnerable to influences and identifying those which can die because of an oil spill. For instance, it is obvious that for plankton with its large number and ability to restore population quickly influence of oil won't be as dramatic as for sea birds and mammals. Sea birds and mammals feeding on water are much more vulnerable during molt period (due to total organism weakening) or during young parenting period when instincts do not allow leaving polluted water area cutting adrift own nestling or cubs. Although if sea birds and animals with large number of population and broad habitat have a larger restoration potential, rare (inconsiderate in number) species can be completely destroyed in case of a large spill in the area of their habitat. The above-mentioned considerations are to be taken into account during the development of maps of ecologically vulnerable zones.

As far as the regions of priority protection are concerned, in Russian Federation (RF) their list is determined by a number of Federal laws, decrees of the Government of RF, legislation of RF subjects and instructions of heads of executive bodies, international agreements, conventions and other legislative documents at various levels. Most clearly the objects subject to special protection are listed in the following legislative documents of RF:

- Federal Law "On protection of environment" dated 10.01.2002 No. 7-FZ (with revisions);
- Federal Law "On specially protected natural territories" dated 14.03.1995 № 33-FZ (with revisions);
- Federal Law "On wildlife" dated 24.04.1995 № 52-FZ (with revisions);
- A Decree of the Ministry of Emergency Situations of RF № 621 "On approval of rules for development and approval of plans in prevention and liquidation of spills of oil and oil products in the territory of RF" dated 28.12.2004.

According to the Russian legislation, objects, zones and regions listed in the above-mentioned documents should receive maximum protection against spills of oil and oil-products. It is well-known that in case of an emergency situation the natural area of shore zone is the most vulnerable to influence of oil pollution. If oil comes in contact with the shore, ecological consequences shall be more negative and long, their variability in the coastland is much higher than for spills in the main sea. This fact determines that vulnerability of shores to oil has been more or less equally estimated for more than 30 years (since an article was published by Gundlach & Hayes [1978]); methods of this evaluation cause no controversy among experts and can be considered as standard.

Taking into account the above-said, the general (integral) maps to be used to plan events in prevention and control of oil spills, shall include the following:

(1) Information about shore ecological vulnerability to oil;

(2) Data on ecological vulnerability to oil of the major components of water (sea) ecological systems, basing on their biological peculiarities (vulnerability, ability to restore), spatial and temporal distribution;

(3) Information about legally protected objects, zones and regions.

OBJECTIVES OF THE RESEARCH

Methodical approached developed by a number of experts shall contribute to increase the effectiveness of environmental actions at various water areas – from the Barents Sea in the North-West of Russia to shores of Sakhalin in the Far East. It is obvious

that such methods can be developed basing on analysis of existing Russian and foreign methods. The objective of this research is to take the best parts of each development, combine them in a natural way, harmonize and include into Russian and international legislation, taking into account local and international experience. At the end the methodology shall be easy enough to be implemented and vivid for various experts who will use it.

The relevance of the research is conditioned by the fact that at present there is no general methodology for development of vulnerability maps in Russian Federation. As a result maps prepared by various developers in the number of cases have significant differences and different amount of information presented. Legislative documents show no requirements to composition, order of compilation and consideration of such maps. The importance of this research is rising as an active development of oil and gas resources has been started at the sea shelves in the North-West and the Far East areas of Russian Federation.

The basic document, taken as a basis for the suggested approach, is a methodology published by the International Petroleum Industry Environmental Conservation Association (IPIECA) and approved by the International Maritime Organization (IMO, where Russia is also a member) in August, 2010 [IMO/IPIECA, 2010]. The most progressive Russian and foreign developments were used as well.

REVIEW OF APPROACHES USED FOR DEVELOPMENT OF ECOLOGICAL VULNERABILITY MAPS

At present approaches used to describe ecological vulnerability of shores and water areas to spill of oil and other dangerous substances vary considerably among the nations. Only a few of them are wide-spread and (with insignificant adaptation and specification) widely used in several or many countries. In particular, one of these is the above-mentions method to evaluate shore vulnerability. This methodology includes use of Environmental Sensitivity Index (ESI) which varies in the range of 1 to 10 grades. As the numerical value of the index increases so increases the vulnerability of the shore to oil pollution. The scale is based on the concept that vulnerability to oil increases together with the increase in protection of the shore against wave influence, in penetration of oil into soil, time of oil presence on the shore and productiveness of marine organisms. This methodology was presented to the general public in the first volume of reports made by International Petroleum Industry Environmental Conservation Association, published together with International Maritime Organization [IMO/IPIECA, 1996]. Later, without any significant revisions, it was repeated in a re-published version [IMO/IPIECA, 2010].

Ecological vulnerability of the offshore zones to oil spills, including coastal water, was characterized by many groups of European experts. Some of the methods are accepted to the legislation of national level. One of them is a Norwegian "Methodology for classification of priority of natural resources to oil pollution in coastal area" [Modell, 2004], approved by the Norwegian Pollution Control Authority (SFT). To our opinion this methodology is over-complicated and leads to uncertain conclusions; it has low clearness of final results. A methodology shall be clear, short, precise, allowing no differing interpretations. One of the remarks to this methodology is an insufficient (and complicated) consideration of seasons. We consider that from the very beginning it is essential to aim at the development of seasonal maps – as the experience shows it is more preferable for decision-makers.

Along with the "Methodology for classification of priority of natural resources...", several regions were selected in Norway as the most vulnerable to oil spills in the Norwegian part of the Barents Sea [Areas..., 2005] per request from the regional department of World Wildlife Fund (WWF Norway). The methodology used included both biological

and economic indicators. Thematic maps included data for (1) bottom sediments and corals; (2) coastal resources; (3) sea birds; (4) sea mammals; (5) fish; (6) fishery; and (7) marine culture. Basing on the results of the work a logically clear and obvious map of integral ecological vulnerability was developed. The only issue which puzzles is why evaluating vulnerability to oil the authors assigned coefficient 3 to fish and sea birds and mammals received only 2, whereas it is well known that in case of oil-spill fish goes away while birds die in large amounts from the direct contact with oil [Patin, 1997]. Anyway the coefficients are specific and if Norwegian experts consider fish to be more valuable than sea birds and mammals they have a certain reason for that.

Danish National Environmental Research Institute has developed an Atlas of ecological vulnerability in coastal zone of Western Greenland in view of oil pollution [Environmental..., 2004 a, b]. This detailed work includes data for (1) regions of extreme and high vulnerability; (2) special protected natural areas; and (3) integral maps of ecological vulnerability.

Specific understanding of priority in protection of components of sea nature is formed by biologists from Finland. According to their views in case of an oil-spill it is necessary to protect not thousands of widespread types of sea birds, but a biotope of a rare species of a bug included into the Red Book [OILECO, 2007]. Maps of vulnerability of sea communities to oil spill are developed in such a way to take sea level into account. Due to the fact that scientists from both Finland and Estonia took part in the mentioned projects, they have similar approaches towards ecological vulnerability of sea.

The organization which prepared first maps of ecological systems that are vulnerable to oil pollution in the Northern Sea was The Joint Nature Conservation Committee, UK [Cartographic services, 1990]. The maps were presented in a comprehensible atlas and were used by national ecological consultants. Later on this work was continued by the Marine Life Information Network for Britain and Ireland [MarLIN, 2005, 2011]. Its experts analyzed advantages and drawbacks of the methods of identification and estimation of vulnerability of organisms (predominantly benthos) to anthropological influence existing at the time the report was compiled. In practice experts from MarLIN use several scales and tables which characterize the data they use. It is worth mentioning that the information system, created by MarLIN, starts with a table which includes a parameter "Evidence/ Confidence" of information regarding the response of various species to influence. Despite the fact that system MarLIN was created only for benthos species and only for Britain and Ireland, at the present time the approach of the authors towards evaluation of vulnerability among sea species seems to be the most well elaborated.

Experts from the Netherlands engaged in solving similar issues in their country, showed interest in maps created by the experts from the Great Britain. They mentioned that the English atlas doesn't include all necessary water areas of the Northern Sea and considers only vulnerability of birds in terms of oil-pollution of the sea. According to their opinion, it was necessary to consider a larger number of components of ecosystems, as well as economic characteristics of the region. In 2001 under the aegis of the Dutch Ministry of transport, public works and water use (Rijkswaterstaat) a project SensMaps was started, which was aimed at creation of maps of integral vulnerability to oil for the Dutch sector of the Northern Sea [Offringa & Lahr, 2007].

The method used by Dutch scientists was suggested by the National Institute for Coastal and Marine Management (RIKZ), located in Hague. The authors underlined that vulnerability maps developed for the region shall allow for making clear and consistent management decisions, and the information obtained shall be integrated into one final index. The compilers of the

review mentioned that there are many different systems for mapping ecological vulnerability in the world, and there are different methods even within the North Sea. Therewith in one country (for example, in the Great Britain) there are often several ones (the same situation is in Russia, see below). Authors specify that in case of a large oil-spill, efforts from several countries may be required. In this case it is necessary to harmonize vulnerability maps, although not all countries agree with that. In particular, at the 7th meeting of the parties, where implementation of the Bonn Convention of 1983 regarding prevention of oil-pollution of the Northern Sea was discussed, many delegations didn't express understanding to create *general* maps of ecological vulnerability [Bonn Agreement, 2005]. It was highlighted that it would be expedient if such information became highly accessible, for example, over the Internet. It would require certain order, pedantic planning, effective communication, periodic update of data and corresponding contracts.

The Dutch method is detailed enough and well-documented; it ends up with a compilation of *integral* vulnerability maps, although it requires deep knowledge in ecology, which was mentioned by the authors. It is not experts from each country that are able to collect such detailed information. In particular, necessary information about biology of many species is missing for Russian seas.

Several heuristic approaches towards development of integral maps of ecological vulnerability of sea water areas to anthropogenic influence (including oil pollution) were suggested in Russia [Pogrebov, Puzachenko, 2003; Novikov, 2006; Pogrebov et al., 2006; Shavykin, Ilyin, 2010; Pogrebov, 2010 a, b]. To a great extent they were the bases of the methodology suggested below.

The latest work related to estimation of sea ecosystems vulnerability to oil spills were the maps of ecological vulnerability of the Baltic Sea, elaborated as a part of the BRISK project held under the aegis of HELCOM (see http://www.helcom.fi/). The most notable conclusion which can be made as a result of this work is that the use of biological characteristics as priority indicators while evaluating integral vulnerability can significantly increase the "contrast" of final maps and more clearly demonstrates its seasonal changes [Sub-regional risk, 2010; Draft, 2011].

CREATION OF METHODOLOGICAL APPROACHES

On the initiative of the World Wildlife Fund of Russia (WWF Russia) from 2008 to 2011 there were 4 working meeting held in Murmansk and Saint-Petersburg between leading Russian experts in evaluation of ecological vulnerability of coastal sea water areas and shores to oil spills in order to develop a unified all-Russian methodology for mapping.

At the first working meeting in February 2008 in Murmansk various Russian and foreign approaches to revealing the most vulnerable coastal-sea zones were considered. A comparative analysis of these approaches allowed selecting most prospective methods of evaluating integral ecological vulnerability of coastal zones for Russian conditions (within the Barents, the White, the Kara, the Laptev, the Black, the Kaspian, the Japan, the Okhotsk, the Chukchi and the East Siberian seas), which were developed by D.Sc. V.B. Pogrebov with colleagues (JSC Ekoproekt, Saint-Petersburg), PhD. A.A. Shavykin (Murmansk Marine Biological Institute) and PhD. Y.Y. Blinovskaya (Institute of Sea Protection, Vladivostok).

The participants of the 1st working meeting mentioned that among Russian methods used, the one which most adequately reflects the ecological situation in coastal zone, is formalized enough and considers tasks and needs of decision-makers is a method to evaluate integral ecological vulnerability created by CJSC Ekoproekt (developers –

D.Sc. V.B. Pogrebov with colleagues) which was tested in practice in a number of water areas of the Baltic, White, Black, Caspian seas and the Sakhalin shelf. It was successfully modified by employees of Murmansk Marine Biological Institute for water area of the Barents Sea.

At the following working meetings the problem of integration of original Russian methods with effectively used European ones was discussed – a Dutch method SafetyatSea [SafetyatSea, 2007], a Norwegian method MOB [MOB, 2000], a method of mapping the ecological vulnerability created by the International Maritime Organization (IMO) and International Petroleum Industry Environmental Conservation Association (IPIECA). The participants of the discussion were scientific and consulting Russian companies – developers of methods for revealing vulnerable zones, nature protection public organizations of Russia, representatives of state bodies and independent experts, engaged in prevention and liquidation of ecological consequences of emergency oil spills, as well as estimation of vulnerability of sea coasts to this type of anthropogenic influence.

According to the results of the 2nd and 3rd working meetings, the group of experts under the aegis of WWF Russia has prepared Methodological approaches to development of maps of ecologically vulnerable zones and regions of priority protection of water areas and coasts against oil and oil products, where authors made an attempt to combine the best Russian and European developments.

On March 16, 2011 the 4th working meeting took place; the aim was to finalize discussion of developed "Methodical approaches to construction of maps of vulnerability to oil pollution of coastal and shore zones" and prepare a Document for Open Discussion (DOD) with interested authorities, potential map users and decision-makers over the Internet, mass-media, etc. The participants of the meeting were A.Y. Knizhnikov (WWF of Russia, head of the Program of ecological policy in oil-and-gas sector, Moscow), M.A. Pukhova (Barents Sea Department of WWF Russia, Murmansk), V.B. Pogrebov (CJSC Ekoproekt, Saint-Petersburg), M.V. Gavrilov (Arctic and Antarctic Research Institute (AARI)), A.A. Shavykin and O.P. Kalinka (MMBI), M.B. Shilin (Russian State Hydrometeorological University, Saint-Petersburg).

The format of the Working meeting was a round-table conference. The facilitator's role was given to A.Y. Knizhnikov who underlined that intensification of nature use at the shelf (in particular – oil extraction and transportation) is impossible without a qualitative increase of scientific control and modernization of the legislative base. As a result of the 4th working meeting all remarks given by experts during first three meetings were taken into account.

During the 4th working meeting three main issues were successfully solved:

1. The scientific-methodological product "Methodic approaches towards development of maps of oil pollution vulnerability for coastal and shore zones" was comprehensively discussed.

2. Revisions, specifications and changes were applied to the product in accordance with recommendations of the experts.

3. Taking into account all revisions and changes a Document for Open Discussion was prepared for further work and promotion.

KEY PRINCIPLES AND AN ALGORITHM FOR DEVELOPMENT OF VULNERABILITY MAPS

The document describes general provisions and main requirements to maps. It is recommended to provide maps in three scales – general plans (scale from 1:10 000 to 1:25 000, for example, for liquidation of the 1st level spills and cleaning of a certain shore area); large-scale (scale from 1:25 000 to 1:100 000); medium- and small-scale

(scale from 1:100 000 to 1:1 000 000, for example, for the initial stage of liquidation of the 3rd level spill).

A principle of scale coordination was elaborated – in order to create maps of integral vulnerability with specific scale data (layers) received within thematic maps of corresponding scale should only be used. Mechanical up-scaling of a map is not allowed. Down-scaling shall be performed basing on generalization of the initial information.

Requirements to map developers were described, and recommendations how to form a working group of experts were given. The next required stage is the choice of seasons, their time limits, and taking regional aspects into account.

As soon as the seasons are determined, a selection of VEC takes place (VEC – Valued Ecosystem Component – is a natural component of an ecosystem which is highlighted among all variety of its components as having specific ecological, economical or social-cultural value). VEC is selected by a group of experts basing on the analysis of available material and is approved by a collective decision.

The chosen VECs are evaluated in terms of their vulnerability to an oil-spill, and thematic maps of their seasonal distribution are created. An example of thematic maps characterizing location of ecologically sensitive areas and regions with priority protection of water areas and coastal zones against spills of oil and oil products is shown in Fig. 1 (the map is created by the specialists of the Environmental Agency ECOPROJECT).

At the same time it is necessary to evaluate the scientific information gathered before development of maps in an unbiased manner, i.e. a conclusiveness of data is important. In some cases a deficit of data doesn't allow evaluating vulnerability and developing a map.

Thematic maps of regions with priority protection of coast and sea water area against oil-spills are created to show vulnerable social-economic objects. The method

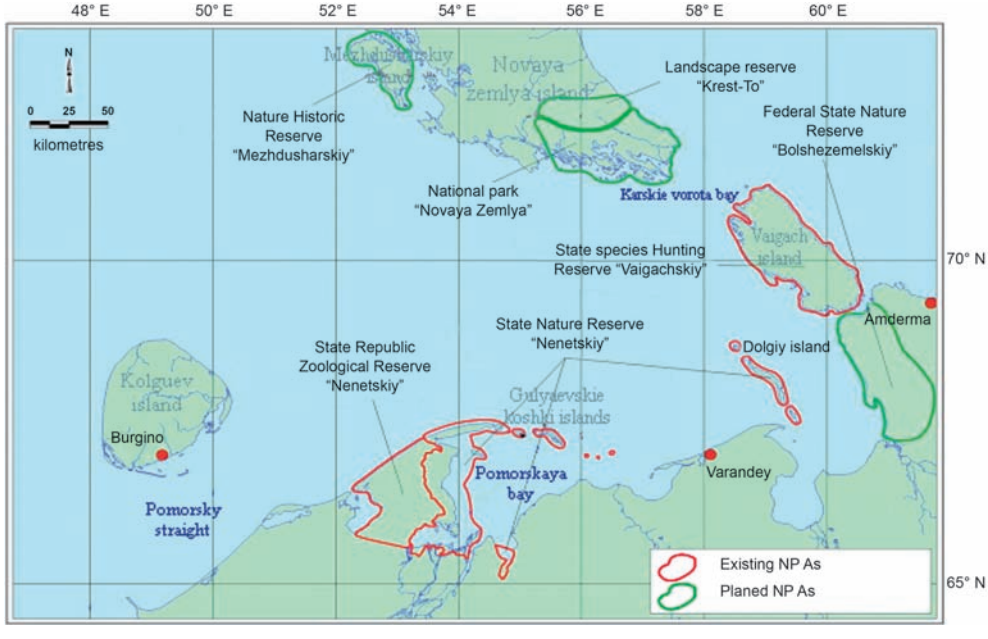

Fig. 1. Location of Protected Natural Areas in the Pechora Sea (the Barents Sea)

suggested by IMO/IPIECA in 2010 includes several categories of such objects:

- Subsistence of local population and its economy, commercial fishery, sea food production, hunting;
- Aquaculture;
- Water consumption (water desalination works, salt extraction, water intake structures for cooling of industrial objects);
- Tourism and community recreation (hotels, restaurants, yacht harbors, beaches, recreational fishing zones, resorts, diving areas);
- Operation of dockyards;
- Industrial production (in particular, basing on sea transport);
- Infrastructure related to oil exploration, extraction and transportation;
- Cultural heritage objects.

Maps of priority protection areas must show nature protection areas, as they are usually regions with high life concentration and therefore require special protection.

Thus, in accordance with the Methodical approaches, maps of integral vulnerability of the considered water area shall include:

- Thematic maps of distribution of selected VECs;
- Nature protection areas of various level (included designed ones);
- Important and vulnerable social-economic objects.

Information about ecological vulnerability of shores is used to compile maps of shore vulnerability. Difficulties in registration of ecological vulnerability of shores at the maps showing integral vulnerability of water area arise due to the fact that if we combine maps of shores and maps of the whole water area the shore line is negligibly narrow at any scale, despite its importance. Because of this the experts developing plans for prevention and liquidation of oil-spills prefer to have separate maps of shore vulnerability.

Selection of vulnerability coefficients is an important stage of developing vulnerability maps.

It is recommended to base the evaluation of types or groups of species on their vulnerability and ability to restore. It is also necessary to take into account the behavior of various types of oil in water. Light oil evaporates easily; oil with average density remains in a water column down to 10 m; heavy oil gradually descends to the bottom. These differences in behavior of various types of oil condition cause dissimilar environmental effects. In particular, the possibility of contact of the organisms living at various depths with an oil-spill would be different depending on oil properties.

Basing on expert evaluations vulnerability coefficients are settled down taking into account the influence of various types of oil and are put into a special table. If it is impossible to perform an analysis or there are no data about interaction between different types of oil and biota, a column with total coefficient of vulnerability is filled out. In order to determine the coefficients special intermediate tables were compiled.

Separately a principle of regionalization was highlighted in the methodical approaches – at all stages of work it is important to take into account regional peculiarities of natural-climatic conditions (selection of seasonal limits), populations and communities (conservation status, behavioral features, dynamics in number, distribution among biotopes, migration time, etc.), social-economic factors (distribution and forms of traditional nature use, other forms of using natural resources). Consideration

of these factors leads to elaboration of regional-specific vulnerability evaluation, ability to restoration, vulnerability and priority protection, i.e. to regionalization of evaluation coefficients.

It was mentioned that taking into account the insufficiency of objective data regarding vulnerability of VEC, it is necessary to use the best world practice as well as to intensify the scientific research activity in this area in Russia.

An important stage for evaluation of VEC vulnerability and priority in protection of regions is the choice of a scale to be used. Basing on ESI index, it would be a 10-point scale for the characteristics of shore vulnerability. In a method suggested by IMO/IPIECA, 2010 the number of grades of shore types is 21, due to use of letter-based designation, and 15 colors are used to show them in maps. For other objects a vulnerability scale with 5 grades, starting from 1 (very low vulnerability) to 5 (very high vulnerability) is the most preferable.

Integration of information in maps, created at previous stages of work, is performed using the geographical information system (GIS). Integral vulnerability of a region is determined as a sum of (1) protection priority of regions (areas) of water areas and shores, (2) vulnerability of water areas and coastal zones, basing on total vulnerability of VECs within their limits. In this case the quantitative estimation of an integral ecological vulnerability of the region shall change in space and time in accordance with the dynamics of seasonal vulnerability of VEC and priority in protection of some social-economic objects (for example, beaches and harbors). Shore vulnerability maps are compiled separately.

At this stage all objects shown in thematic maps at previous stages are subject to digitizing and presented as separate layers in the GIS. Thus, a separate GIS layer is created for a map of each species / group of species. A regular net is created as a separate layer, size of cells is determined basing on minimum sizes of contours on thematic maps, or a cell size equal to 1 mm is set for maps with any scale. Further it is necessary to determine data about distribution of objects (abundance indicators) for each cell of each thematic map. After this the corresponding property table fields for each object of a thematic layer are filled out with information about presence of the object at this territory in particular season, and/or indicators of its abundance.

Calculation of vulnerability for a species i for each cell of a regular net is performed by formula

$$h_i = d_i h_{ci},$$

where d_i is a weight characteristics of a cell in a regular net for this type, showing abundance and occurrence of a species; h_{ci} is a coefficient of species vulnerability.

In this case cells receive different values, from minimum – for example, 20, to maximum – 1500. Total values of vulnerability, obtained for each cell, are ranged according to 5-grade scale. For the purpose of adequate mapping, the values are ranged using "floating border" – in the most vulnerable seasons, so that a clear scale of all 5 colors can be seen. Then a calculation of integral vulnerability for each cell of a regular net is made, a histogram is built (distribution of an integral vulnerability according to a range of values for all seasons) and the minimum and maximum values of integral vulnerability are determined.

The ranging should take into account data of all seasons, so that the total estimation scale accounts for seasonal variability; in this case we can obtain maps with absolute integral vulnerability. Ranging taking into account data obtained for each specific season is made as well – in this case we obtain maps of relative integral vulnerability.

It is recommended to construct maps according to a scale of integral vulnerability,

divided into five equal intervals from the minimum value of integral vulnerability to the maximum one. In case a clear graduation of all 5 colors can't be followed, for the purpose of adequate mapping the values could be ranged using "floating border", i.e. the values are ranged randomly.

Maps of integral vulnerability of several sea water areas of RF, compiled by using the suggested method are shown in Fig. 2 and 3 (these maps are also created by the specialists of the Environmental Agency ECOPROJECT).

Integral vulnerability in Fig. 2 and 3 is characterized by five grades in colors from red – "very high vulnerability", through yellow – "average vulnerability", to green – "insignificant vulnerability". Such "traffic-light" schemes allow selecting the most

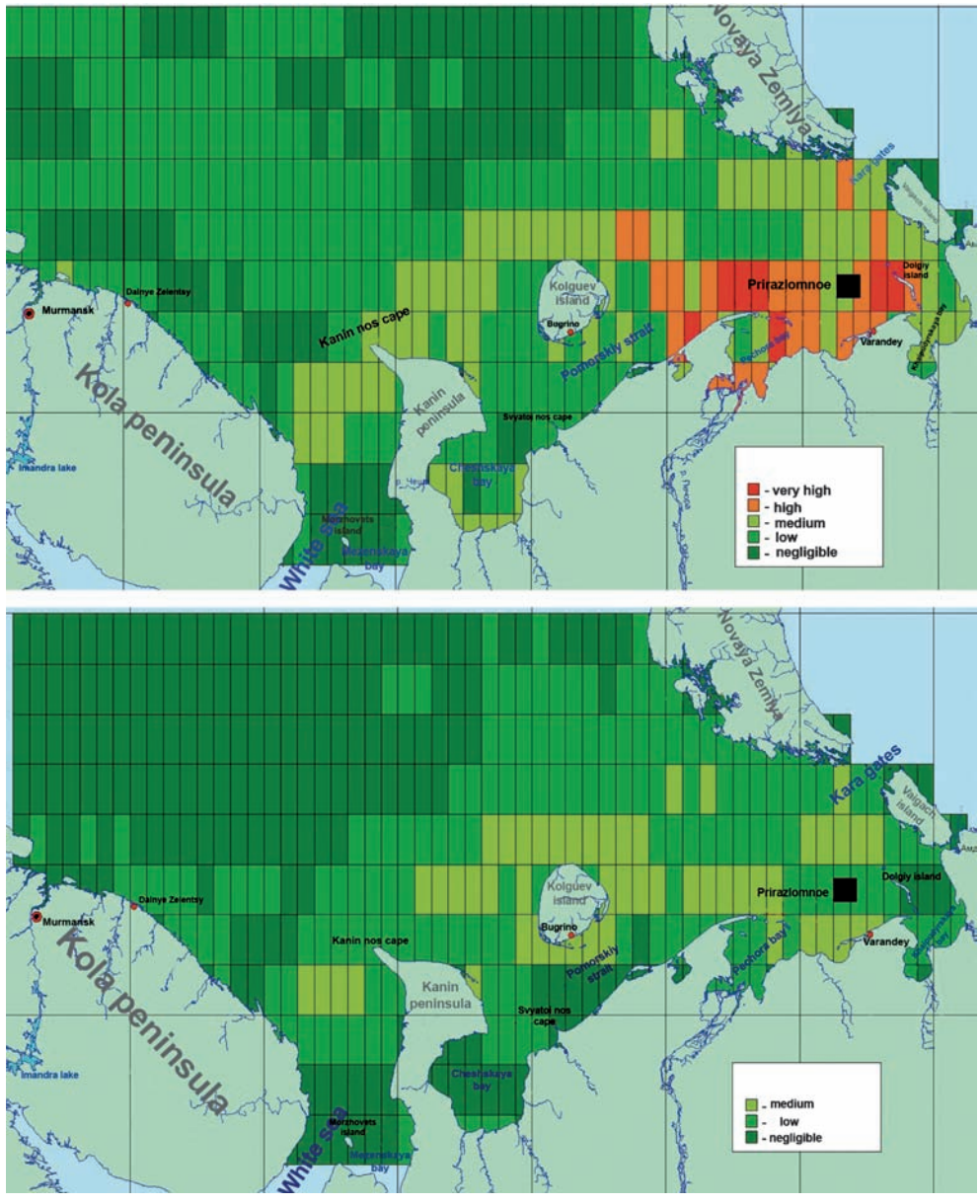

Fig. 2. Integral vulnerability of the southern part of the Barents Sea to oil spills in spring (above) and in winter (below)

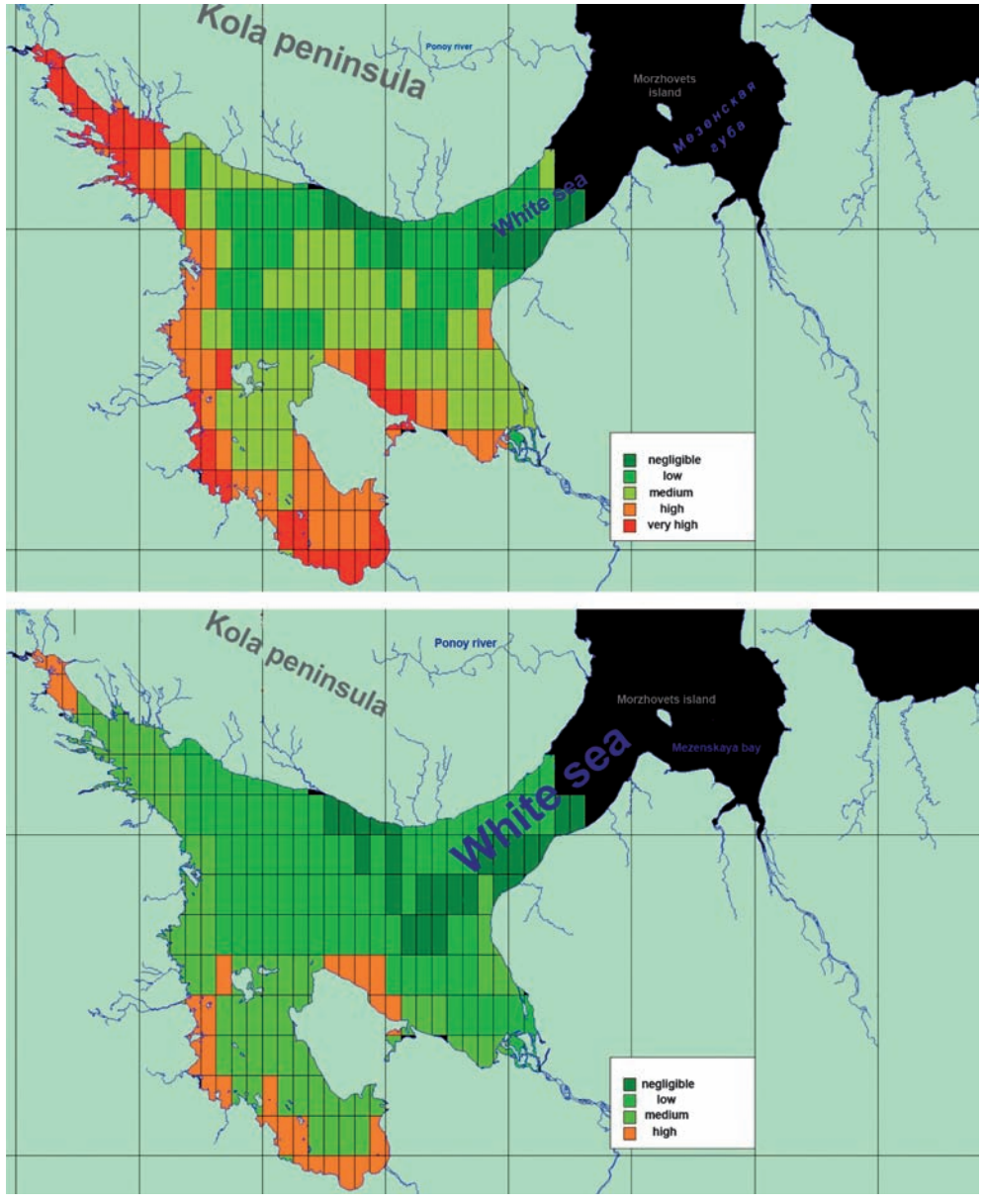

Fig. 3. Integral vulnerability of the White Sea to oil spills in summer (above) and in winter (below)

appropriate measures to liquidate oil-spills in case of emergency, basing on the importance to protect certain regions or objects. Simultaneous consideration of all seasonal integral vulnerability maps without any detailed explanations allows (1) determining the most vulnerable areas or regions of the considered water area and (2) following changes in sea vulnerability to oil-spills throughout the year. The maps should be constructed in the same range scale with the same numerical values of borders between range intervals.

The next step is presentation of the results as a series of maps (eight maps in each series) according to seasons (spring, summer, autumn, winter) for absolute and relative integral vulnerability.

A set of maps showing absolute and relative integral vulnerability of the considered

water area allows analyzing spatial-temporal dynamics of this indicator for the considered region throughout the year. At the final stage a general analysis of created maps is made. The most vulnerable areas (regions) of the water area are selected, as well as the most vulnerable seasons. Recommendations are elaborated in order to organize the most effective protection of the environment against any possible emergency spills of oil and oil products.

It is particularly necessary to show the logistical and operational resources which include the following components:

- Detailed information necessary for the heads of groups engaged in liquidation of oil-spills to take measures;
- Location of control points and their responsibility areas;
- Places for storage of equipment;
- Pre-approved areas for use of dispersants and their geographical limits;
- Zones provided with environmental recommendations to limit the impact of oil spills and of the cleaning operations (which is particularly important for high-vulnerability areas);
- Centers for rehabilitation of injured animals.

These resources are to be included into final vulnerability maps and can be presented as a separate layer in GIS, where their location can be changed if and when necessary.

CONCLUSION

The 2010 Deepwater Horizon disaster in the Mexican Gulf has attracted attention of decision makers, scientists and general public all over the world to the problem of environmental safety of the offshore oil & gas activities. The Arctic Council, an intergovernmental body, that is responsible to find ways for sustainable development in the Arctic basin, has taken seriously the problem of prevention and combat oil spill in the Arctic after the disaster. At the Arctic Council meeting in Nuuk, Greenland, May 2011, the Declaration was adopted. Among other important issues the following decision has been made:

Decide to establish a Task Force, reporting to the SAOs, to develop an international instrument on Arctic marine oil pollution preparedness and response, and **call** for the Emergency Prevention, Preparedness and Response (EPPR) and other relevant working groups to develop recommendations and/or best practices in the prevention of marine oil pollution; the preliminary or final results of both to be presented jointly at the next Ministerial meeting in 2013.

Mapping of vulnerability for oil spills is one of the key components of any Oil Spill Response (OSR) program. Recently the IMO/IPIECA "Guidance on sensitivity mapping for oil spill response" was adopted at the international level. The Methodological Approaches for sensitivity mapping of the RF coastlines and seas in case of oil spills, developed by key Russian scientists on OSR issues with the WWF Russia support is an important step to implement the best international practice in Russia. As soon as the new offshore oil & gas development in Russia is going to take place mostly in Arctic or Sub-Arctic, the developed Methodological Approaches will be in correspondence with the Arctic Council decision on OSR. The Methodological Approaches are also aimed to fill up the gap in the Russian legislation as soon as sensitivity maps is required by a number of Government decrees but there is no common and approved methodology of their compilation. The absence of such methodology makes it impossible to produce sensitivity maps in Russia with proper quality, so it's not possible to develop and implement effective OSR activities.

Based on the developed Methodological Approaches, the raw, initial data of the

ecosystem feature is one of the core factors for the proper quality of sensitivity maps. For the Arctic it is other challenge as soon as there is absence of such data for many features (species, habitats, processes). So, such gap in ecosystem knowledge should be filled up in advance of any sensitivity mapping exercise.

WWF Russia is going to provide further support for practical implementation of the developed Methodological Approaches in Russia. On the one hand, the national standard will be developed basing on Methodological Approaches and submitted to authorities for approval later this year. On the other hand, WWF Russia will continue to support scientific research of key Arctic ecosystem features like rare species (Atlantic walrus, Polar bear, etc) as well the most fragile and important habitats (spawning areas, rookery, etc). WWF Russia is also interested to cooperate with other Arctic governmental and nongovernmental organizations in terms of discussion and developing of the Arctic-wide methodology on sensitivity mapping on oil spill response. ■

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