Conference Paper

Aspects for Priority Protection Assessment of Abiotic Components to Oil Exposure

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Abstract

The analytical review was prepared to assess coefficients of priority protection the features of special significance for mapping the vulnerability of marine coastal zones from oil pollution. Nowadays, this issue is a rather complex scientific problem, because there is no consensus on how to evaluate, calculate and how to present them. In most cases, such coefficients are given by one or more parameters in relative units (points, ranks). As a rationale, only criteria are given, taking into account which it is determined how much one object is more important for protection than another, and specific values are based mainly on the subjective expert's opinion and are therefore ambiguous. At the same time, the availability of maps showing the environmental vulnerability of marine coastal zones is very important in case of emergency oil spills, as it facilitates the indicating of priorities for cleaning, especially at the initial stages of spill response and minimizes potential damage to the natural and man-made environment. This paper proposes approaches, where the basis for obtaining quantitative standardizable indicators of priority protection the features of special significance presented with minimal subjectivity and maximum generality.

Keywords: oil pollution, vulnerability maps of marine coastal zones, priority protection, features of special significance

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1. Introduction

Within the fact that the production and transportation of oil and oil products in the sea pose a potential danger of emergency spills and oil pollution, an effective oil spill prevention and response system is required. According to the recommendations of international organizations, the critical element of preparedness is ``making and updating sensitivity maps are key activities in the oil spill contingency planning process. These maps convey essential information to spill responders by showing where the different coastal resources are, and by indicating environmentally sensitive areas'' [1, 2]. Several years ago in Russia, an attempt was made to create a methodology for mapping the vulnerability of marine coastal areas [3]. However, the key issues related to the vulnerability factors of biota and abiotic components were not worked out at the proper level. In the world practice of developing vulnerability maps, the same problem is observed, the parameters are used in relative units (points, ranks), [4]. Further, if the arithmetic operations are carried out with ranking values, which is unacceptable [5--7], the final maps will not represent the correct result. In the works of a group of scientists from MMBI KSC RAS, the above situation, that the coefficients used for calculations must be metric (in absolute units), was highlighted more than once. The authors show options for solving the problem of vulnerability coefficients for biota [8, 9]. But any possible solution was not given for abiotic components. The present analytical review describes ways for estimation priority protection the features of special and possible solutions are proposed for obtaining indicators of priority protection on a metric scale with minimal subjectivity and maximum generality.

2. Methods and Equipment

Dealing with constructing maps of the integrated vulnerability for coastal-marine zones from oil exposure, three groups of resources are taken into account: 1) valued components of biota (VCB); 2) various environmental, economic and socio-cultural features of special significance (FSS); 3) existing and planned nature conservation areas (NCA). These objects are generally potentially vulnerable to possible oil spills and may be adversely affected by such spills. To determine how much one object is more important for protection than another, vulnerability coefficients (for VCB) and priority protection coefficients (for FSS) are used. Their assessment is a rather complicated scientific problem, therefore, to solve it, it is necessary to attract qualified specialists who are competent and well familiar with this issue. The issues related to the determination of priority protection coefficients for FSS are discussed below.

In various sources, the following main especially significant environmental, economic and socio-cultural objects that require priority protection are highlighted:

- ecologically significant areas (key seabird and mammal habitats, fish breeding and feeding grounds, the concentration of broods of birds, accumulation of commercial invertebrates; reproduction areas for crabs and development of their larvae);

- areas of production (economic) activity (areas of industrial fishing, production of benthic invertebrates, seaweed; areas of cultivation of mariculture; infrastructure related to the exploration, production and transportation of oil; hydraulic and port facilities);

- recreational areas (beaches, recreational fishing areas, spa areas, scuba diving places, floating hotels, restaurants and cafes, yacht harbors);

- historically significant and cultural areas (cultural heritage sites, floating museums).

A literature searches and analysis of existing assessments for the importance of various ecological, economic, socio-cultural resources and conservation areas showed that there are three main approaches to determine their priority protection.

2.1. Simple ranking

The degree of value or significance of the objects / resources taken into account is determined by assigning them ranks / points at a qualitative level (i.e., not on a metric scale, but an ordinal scale, when a number in relative units is taken as a number in an increasing sequence of values). This approach is used in the following methods [3, 10--25]. Based on expert knowledge, needed coefficients are ``evaluated'' on an ordinal (rank) scale here. In most cases, this algorithm allows the absence of detailed source data and complex transformations to obtain the final value of the priority protection coefficients. The main problem and difficulty here are to reach a consensus in opinions of various specialists.

2.2. Calculation of coefficients based on quantitative characteristics and parameters.

Frequently, the assessment of priority protection is presented in monetary terms through damage, lost profits, the cost of restoration, etc. [26--28]. It is often not always possible to give such estimations. This is especially true for non-commercial resources, for example, environmental objects (reserves, reserves, national parks, natural monuments). A rough quantification of environmental vulnerability not through monetary damage has been proposed and applied by the South Pacific Applied Geosciences Commission [29, 30].

2.3. Semi-quantitative estimation of priority protection coefficients

The combination of mentioned above two approaches. A number of papers recommend the use of a matrix based on two or more parameters to determine vulnerability or sensitivity (in fact, the priority of protection of different resources), when one of the axes can be considered quantitative and the other ordinal [2, 21, 31]. Also, for each type of resources, a "ranking" of the parameters characterizing the resources taken into account is carried out, depending on the numerical values of these parameters (the conversion of numerical values into dimensionless points, often without preserving the original relations between the values) [32--35].

3. Discussion

It should be noted that it is not permissible to apply a simple ranking of the relevant parameters (on an ordinal scale), if further calculations are assumed with them [5--7, 36] or a comparison of how quantitatively one of the resources or objects is more significant or more valuable than the other. The semi-quantitative expression for indexes using different scales (quantitative and qualitative) and transformation from heterogeneous input data (when a part of them are converted into grades with violation of the initial proportions and ratios originally used absolute values) leads to incorrect calculation of the coefficients take into account the priority protection of the resources. But in many existing approaches and methods, this algorithm is still used. To determine the priority protection coefficients of the considered resources and objects, initial data are required based on quantitative characteristics and parameters presented in absolute or appropriate relative (metric) units. For this, the most common is monetary valuation (through damage, lost profits, restoration costs, etc.), ``understood by everyone'' and allowing comparison and different calculations to be made in absolute values that do not distort the initial ratios of the considered parametric characteristics. This approach requires a large amount of detailed information on each of the resources and their properties for each specific case.

It is hardly possible to determine in advance a unified correct coefficient of priority protection for one or another resource under consideration (FSS) because it should be calculated for a particular region and depend on the conditions and factors of the situation under consideration. Therefore, well-qualified professionals who are competent and familiar with the issues in a given region should identify the list of resources to be considered, as well as to determine the parameters that quantify priority protection factors.

4. Results

In general, the most optimal and correct unified estimates can be given on the basis of a synthesis of long-term data, for example, on costs of a different nature from oil spills, expressed in monetary terms for their use in specific cases [27, 29, 30]. For example, D. S. Etkin developed universal Basic Oil Spill Cost Estimation Model (BOSCEM) for estimating oil spill costs, including response costs and environmental and socioeconomic damages, for actual or hypothetical spills [27]. The model is based on updated cost data collected from case studies of over 300 spills in 40 nations that occurred during the years 1980 through 2002. Each spill was classified by the input criteria of oil type and volume and general location-specific characteristics to determine the appropriate cost modifiers. To calculate socioeconomic damages, multiply the base per-gallon socioeconomic cost based on oil type/volume by the appropriate socioeconomic and cultural damage cost modifier and by the spill amount.

Taking into account the publications [28, 37] can be proposed following formulas for calculation of priority protection coefficients for the next types of FSS:

4.1. Assessment of economic damage caused by emergency oil spills to commercial bioresources (unearned income from fishing activities):

$$Y^b = \sum_{i=1}^{n} \sum_{j=1}^{m} \left(U_i \left(Q_{ij}^q - Q_{ij}^I - Q_{ij}^{II} \right) + Q_{ij}^{II} \left(U_i - U_i' \right) + R_i \right) \qquad (1)$$

where: i - types of biological resources; j - commercial enterprise; U_i -- unit economic assessment of the i -th type of bioresources in initial quality, rubles/ton; $Q^q{}_{ij}$ - catch quota for the i-th type of biological resources to the j-th enterprise, tons; $Q^I{}_{ij}$ - the actual amount of catch of the i-th type of biological resources in initial quality by the j-th enterprise, tons; $Q^{II}{}_{ij}$ - the actual catch of the i-th species of bioresources transformed as a result of the spill, of poor quality, tons; U'_i - unit economic assessment of the i-th type of transformed bioresources, rubles/t; R_i - additional costs for the reproduction of the i-th type of biological resources, rubles/t.

4.2. Assessment of economic damage caused by oil spills to the reproduction of biological resources in artificial conditions (mariculture):

$$Y^e = \sum_{i=1}^{n} P_i + R_i^e \qquad (2)$$

where: Y^e -- the value of the damage caused by pollution of fish-breeding factories and farms mariculture; n -- number of enterprises that suffered damage; P_i -- the value of the lost profit of the i-th enterprise; R_i^e-- the cost recovery activities of the i-th enterprise.

4.3. Assessment of damage caused by emergency oil spills to recreational natural resources of the water area, shores and coastline:

$$Y = Y^{rr} + Y^{rs} + Y^{t} + Y^{cu} + Y^{hf} \tag{3}$$

where: Y - damage from the reduction in the direct cost of using recreational resources (Y^{rr}), equal to the amount of losses incurred for recreational services (Y^{rs}), tourism (Y^{t}), collateral use (Y^{cu}), and hunting and fishing activities (Y^{hf}).

4.4. Assessment of damage caused by emergency oil spills to transport resources of the water area and port facilities:

$$Y^{t} = R_{v} + \pi^{p} \tag{4}$$

where: R_{v} -- additional vessel operating costs resulting from downtime and(or) by changing the vessel route for bypass the places of purification from oil; Π^{p} -- payment penalties on contracts, claims for breach of obligations.

5. Conclusion

The analytical review has been prepared to assess the priority protection coefficients for features of special significance (FSS) to make the vulnerability maps of marine coastal zones from oil pollution. It was revealed to determine the priority protection coefficients of the considered resources and objects, initial data are required based on quantitative characteristics and parameters represented in absolute or corresponding relative (metric) units. Otherwise, if the arithmetic operations are carried out with them, the resulting vulnerability maps will not show the correct result.

The most optimal and proper unified estimates for FSS can be given based on summarizing long-term data, for example, on costs of a different nature from oil spill response. For this, the most common is monetary valuation (through damage, lost profits, restoration costs, etc.), ``understood by everyone'' and allowing comparison and different calculations to be made in absolute values that do not distort the initial ratios of the considered parametric characteristics.

The propose d approach requires a large amount of detailed information on each of the resources and their properties for each specific case. Therefore, well-qualified professionals who are competent and familiar with the issues in a given region should identify the list of resources to be considered, as well as to determine the parameters that quantify priority protection factors.

Conflict of Interest

The authors have no conflict of interest to declare.

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