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ТЕОРЕТИКО – ПРИКЛАДНІ ЗАСАДИ ФОРМУВАННЯ ІНФОРМАЦІЙНО-АНАЛІТИЧНОГО ЗАБЕЗПЕЧЕННЯ ЗАХИСТУ МОРСЬКОГО СЕРЕДОВИЩА ВІД ЗАБРУДЕННЯ СУДНАМИ

Актуальність. *Актуальність проведеного дослідження обумовлюється тим, що зростають динамічність процесів забруднення моря і потужність та нерівномірність інформаційних потоків, які супроводжують процес забруднення. Це вимагає створення інформаційно-аналітичної системи для підтримки прийняття рішень щодо ефективного запобіганню забруднень та ліквідації їх наслідків. А створення такої системи, в свою чергу, вимагає досліджень теоретико - прикладних засад її формування.*

Мета та завдання. *Основною метою дослідження є розвиток теоретико - прикладних положень щодо особливостей формування інформаційно-аналітичного забезпечення морського середовища від забруднення та розробка системних підходів і математичного апарату проектування каналів передачі інформації та забезпечення ефективного Traffic Engineering.*

Результати. *Досліджено теоретико - прикладні засади формування інформаційно аналітичного забезпечення захисту морського середовища від забруднення судами. Виявлено особливості формування, в першу чергу, пов'язані з існуючою розгалуженою нормативно-правою базою захисту акваторії від забруднення. Виявлені механізми забруднення та притаманні їм характеристики інформаційних потоків, що вимагає застосування методів Traffic Engineering. Запропонована математична формалізація для ефективного проектування каналів передачі інформації та забезпечення ефективного Traffic Engineering. Запропоновано підхід до оцінки ефективності процесу передачі інформації та, як основний критерій в Traffic Engineering для ІАЗЗМС - коефіцієнт використання ресурсу. Формалізовано алгоритм перед проектної перевірки пропускної здатності маршрутів інформаційної системи за динамічного варіанту обробки інформації.*

Висновки. *В представленій статті досліджено теоретико - прикладні аспекти формування єдиного інформаційно-аналітичного забезпечення захисту морського середовища, зокрема, ті особливості, що обумовлені існуючою нормативно-правовою базою та наявними механізмами забруднення. Створено математичний апарат проектування каналів передачі інформації та забезпечення ефективного Traffic Engineering. Запропоновано підхід до оцінки ефективності процесу передачі інформації та, як основний критерій в методі Traffic Engineering для ІАЗЗМС - коефіцієнт використання ресурсу. Формалізовано алгоритм перед проектної перевірки пропускної здатності маршрутів інформаційної системи за динамічного варіанту обробки інформації. Все це дозволяє створити необхідні умови формування єдиного інформаційно-аналітичного забезпечення захисту морського середовища.*

Ключові слова: *підтримка прийняття рішень, інжиніринг трафіку, traffic engineering , information flows, управління рухом інформації, математична модель*

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THEORETICAL - APPLIED PRINCIPLES OF FORMATION OF INFORMATION AND ANALYTICAL SUPPORT OF PROTECTION OF THE MARINE ENVIRONMENT FROM VESSEL POLLUTION

Topicality. *The relevance of the study is due to the fact that the growing dynamics of marine pollution and power and uneven information flows that accompany the pollution process. This requires the creation of an information-analytical system to support decision-making on effective pollution prevention and elimination. And the creation of such a system, in turn, requires research on the theoretical and applied principles of its formation.*

Aim and tasks. *The main purpose of the study is the development of theoretical and applied provisions on the peculiarities of the formation of information and analytical support of the marine environment from pollution and development of system approaches and mathematical apparatus for designing information transmission channels and ensuring efficient Traffic Engineering.*

Research results. *Theoretical and applied bases of formation of information-analytical maintenance of protection of the marine environment from pollution by ships are investigated. Peculiarities of formation, first of all, connected with the existing branched normative-legal base of protection of water area from pollution are revealed. The mechanisms of pollution and their inherent characteristics of information flows are identified, which requires the use of methods Traffic Engineering. Mathematical formalization is proposed for efficient design of information transmission channels and ensuring efficient Traffic Engineering. An approach to assessing the effectiveness of the information transfer process and as the main criterion in*

Traffic Engineering for ISMP - resource utilization factor. The algorithm before the design check of the bandwidth of the information system routes under the dynamic variant of information processing is formalized.

Conclusion. *The presented article investigates the theoretical and applied aspects of the formation of a single information and analytical support for the protection of the marine environment, in particular, those features that are due to the existing regulatory framework and existing pollution mechanisms. A mathematical apparatus for designing information transmission channels and ensuring efficient Traffic Engineering. An approach to assessing the effectiveness of the information transfer process and as the main criterion in the method is proposed Traffic Engineering for ISMP - resource utilization factor. The algorithm before the design check of the bandwidth of the information system routes under the dynamic variant of information processing is formalized. All this allows creating the necessary conditions for the formation of a single information and analytical support for the protection of the marine environment.*

Keywords: *decision support, traffic engineering, information flows, information traffic control, mathematical model*

Problem statement and its connection with important scientific and practical tasks. The formation of the support and decision-making system (DSS) for water pollution is closely related to the peculiarities inherent in the creation of this system, the need to take into account the various mechanisms that lead to marine pollution by ships in coastal waters of Ukraine. Therefore, for the effective and reliable functioning of the information-analytical system it is necessary to consider the theoretical and applied

principles of its creation, to explore current theoretical approaches to pre-project work. The introduction of a single information and analytical support for the protection of the marine environment (ISMP) from pollution by ships will significantly improve the quality of work on the protection of the marine environment; increase the effectiveness of control and the inevitability of legal liability for damage.

The need to form ISMP today is due to the need to increase the efficiency of public administration in the field of environmental protection, Ukraine's implementation of international obligations and treaties, guaranteeing a certain level of safety of maritime transport routes, on the one hand. On the other hand, the need to introduce a new information approach to this problem is due to the growing dynamics of the processes of transportation of goods by sea; increasing the amount of information that must be operated to make optimal decisions in real time; he need to take into account a significant number of factors that affect the result, taking into account the uncertainty of a number of indicators; increasing the importance of the consequences of decisions made by managers. All this leads to an increase in the importance of an effective and reliable system of information and analytical support for the protection of the marine environment.

Analysis of recent publications on the problem. The problem of formation of ISMP has two aspects - protection of water area from pollution by vessels and methodology of creation DSS. Problems of protection of water areas from pollution were investigated in the work Matus (2019) [1], Zhykharieva (2016) [2], in the monograph Shestopalov (2015) [3]. This problem has been studied in detail and thoroughly by specialists of the Central Geophysical Observatory named after B. Sreznevskoho (2019) [4], Nabyvanets (2017) assessed the impact of the armed conflict in eastern Ukraine on surface water quality, which became part of the report Organization for Security and Co-operation in Europe [5]. The report of the International Bank for Reconstruction and Development is devoted to the analysis of the environment, in particular, the Black Sea-Azov basin [6]. Legal aspects of water pollution are considered in the works Aleksieieva (2019) [7]. Developments of the NAS of Ukraine on the system of forecasting the course of emergencies of natural and man-made nature are presented in the report of the NAS of Ukraine [8]. Dziuniak (2017) [9] presented information technology for estimating the parameters of emissions of harmful substances. Lobodoiu (2014) the use of information technologies for environmental protection is analyzed [10]. These scientific works have created the necessary basis for the formation of a single information and analytical support for the protection of the marine environment. But this DSS must meet the challenges that are specific to it, the institutional and institutitutionalizmal conditions that shape its features.

Preservation and protection of the natural resource potential of the marine environment from pollution by ships has two main directions, respectively, the two main mechanisms of pollution. The first mechanism of pollution is due to man-made disasters and shipwrecks. The second mechanism is directly related to the day-to-day operation of the cargo transportation system. This leads to the existence of two mechanisms for managing the environmental and man-made safety of the marine environment, which requires the formation of a single IAAS from ship-source pollution and which must be combined into a single system.

The existence of this DSS is due not only to the need to perform the main task, namely - conservation and protection of natural resources, especially the marine environment, from ship pollution, but also the safe use of watercraft, saving lives and health in the short term and in the long run, for future generations.

Thus, not only state institutes and institutions but also far-sighted commercial structures should be interested in the formation, proper functioning and support of this system of information and analytical support. First of all those who are engaged in transportation of cargoes by sea vessels and who too should be presented in DSS by their information resources. They must also have access to DSS as users. The combination of interests of commercial and government agencies is one of the features ISMP.

Work on the first of these mechanisms should go in accordance with the following areas:

- ensuring trouble-free operation of ship equipment and relevant shore infrastructure and reliability of information flows about it;
- exclusion of the human factor (including reporting on training of crews and shore infrastructure workers, compliance with staff regulations, etc.);
- formation of a system of risk analysis, their reduction and prevention of their occurrence, minimization of consequences in case of their implementation;
- formation of a security system against malicious acts, terrorist acts, sabotages.

The existence of the second mechanism of pollution requires constant and reliable monitoring of compliance by crews with established norms and rules and ensuring end-to-end control of this.

In accordance with these areas and should be formed ISMP. It should include information and analytical support (hereinafter, respectively, directions 1-3 of the first mechanism): trouble-free operation of

ship equipment and relevant coastal infrastructure, to promote the exclusion of the human factor; provide risk analysis and minimize their consequences.

Information and analytical support of each of the directions of the first mechanism is different in its tasks, and in its content, and in its implementation. But the presence of two different mechanisms leads to the emergence of two modes of DSS - with moderate loading of information channels in the presence of only the second mechanism (call it static mode), and excessive, crisis loading of channels characteristic of the first mechanism (dynamic mode). The option of excessive redundancy of information channels for possible use in case of crisis will lead to a significant increase in the cost of the system, which is unacceptable.

The presence of such discrepancies leads to the need to implement before the design assessment of the bandwidth of transmission channels and the use of Traffic Engineering methods for the whole Data Base and for the system of collection and transmission of primary information on the post-emergency situation and forecasting possible threats.

Allocation of previously unsolved parts of the general problem. To form a single information and analytical support for the protection of the marine environment, it is necessary to create a mathematical apparatus for designing information transmission channels and ensuring efficient Traffic Engineering. The regulatory field on marine pollution includes more than three hundred normative and legal acts of Ukraine and must comply with the whole body of international norms on environmental protection, which creates significant requirements for the functioning of ISMP. Because the information system should help increase the efficiency of both government and commercial structures in this direction, and not create obstacles to the functioning of the existing institutional structure. This requires a study of the design features of the ISMP, due to the specified institutional structure.

Formulation of research objectives (problem statement). The main purpose of the study is the development of theoretical and applied provisions on the peculiarities of the formation of information and analytical support of the marine environment from pollution and the development of system approaches and mathematical apparatus for designing information transmission channels and ensuring effective Traffic Engineering.

An outline of the main results and their justification. Information and analytical support for marine pollution is needed not only to provide the necessary information on the facts of pollution and the genesis and prospects of the ecological situation in the coastal waters of Ukraine, but also to implement and control the necessary regulatory measures to prevent pollution, form appropriate institutional and institutional policies.

Peculiarities of designing the decision support system (DSS) for the pollution of the Black and Azov Seas adjacent to Ukraine are, first, the main mechanisms of pollution. A significant feature of the formation of the DSS is also the eclectic nature of databases and knowledge, information resources, which are created and operate today in accordance with the body of regulations of Ukraine. Legislative and regulatory framework for many years of work of the relevant institutions has contributed to the formation of the existing structure, which provides the accumulation of information on pollution and control of regulatory measures to prevent pollution and eliminate the consequences of accidents and disasters at sea. The body of normative legal acts of Ukraine concerning protection of the environment in general and, in particular, water areas from pollution by vessels is rather thorough (more than three hundred legal acts) and corresponds to the International norms and rules. But this body of regulations today, on the one hand, does not have enough mechanisms and tools for law enforcement, on the other hand, without an integrated system of information - analytical tools, it is not effective enough. From the point of view of formation of the effective state policy of maintenance of protection of the marine environment against pollution by vessels it is necessary not only to create normative-legal base, but also to form necessary tools and mechanisms of encouragement of observance of ecological norms and standards and the corresponding sanctions for their infringement. In particular, to stimulate the increase of capital expenditures on ship and shore equipment to ensure environmental standards and trouble-free operation.

Direct and indirect institutional instruments to protect water areas from pollution should move away from the practice of marginal damage assessment of water areas solely on the basis of data on permissible concentrations of harmful substances and, in accordance with the EU Directive on «Comprehensive Pollution Prevention and Control», move to integrated solutions, technologies, on the one hand, and, on the other hand, to have sufficient information and analytical support for the validity of evidence of harm to punish violators. The effectiveness of this is constrained by the fact that the state institute of environmental protection is to some extent segmented into a significant number of institutions, in particular, the State Ecological Inspectorate; State Agency of Water Resources; ecological structures of regional state

administrations; The Ministry of Environment, which reports to three research institutes and nine state-owned enterprises, etc. Therefore, databases of environmental monitoring control of pollution sources are scattered, which slows down and complicates their joint use. The effectiveness of decision-making is hampered by the need for their coordination. And formal decision-making coordination procedures are largely lacking. This requires the formation of mechanisms for database integration. Such mechanisms can serve to form information and analytical support for the protection of the marine environment from pollution by ships.

Monitoring of the state of the environment and monitoring of compliance with environmental legislation is carried out by a number of institutions, but the effectiveness of their work is limited by the capabilities of obsolete equipment, lack of qualified personnel and limited funding. As one of the tools for implementing the state policy in the field of protection of the marine environment from pollution by ships, it is necessary to form a system of preparation and decision-making on this issue, which will be provided with appropriate databases, data collection programs, their analysis and user interface.

A common approach to the formation of the DSS structure is to implement the modular principle. It is advisable to include the following modules in the structure of ISMP:

- Automatic design and practical adaptation of dynamic analytical models.
- Formation of algorithms for analytical research of knowledge bases and data.
- Systems for processing solutions and analytical approaches.
- Structural synthesis of non-obvious data.

The peculiarity of the system of information and analytical support for the protection of the marine environment from pollution by ships is that this system should analyze the data that accumulate in much industry, departmental, commercial databases. As these databases were created for various technical tasks and were intended for narrow-profile tasks, their direct integration into a single database is impossible for technical, technological and regulatory reasons. It can also complicate analytical data processing and increase the time required to perform information analysis.

Another feature of the system of information and analytical support for the protection of the marine environment will be that the data of each of the existing databases are a commercial, departmental or even state secret. Their integration, the possibility of their joint analytical processing will increase the importance of these databases for individuals and organizations that do not have and should not have access to information of this degree of secrecy. This will require special treatment for the protection of existing databases.

The next feature of ISMP will be that users will need analytical information not only on unified inquiries, but also on individual, specific inquiries, especially in case of non-standard crisis situations. In addition, it is obvious that users of analytical information on the specifics of their work (monitoring, supervision, stay on board the ship, etc.) will be geographically dispersed. All these features will require the use of closed (so-called "private") cloud-resources and, accordingly, the transfer of existing auxiliary databases of this profile to closed cloud-resources. The transfer of existing corporate, departmental, industry databases, which become ancillary to the system of information and analytical support of marine environment, to the cloud-resource will result in the fact that users and administrators of these databases will not be able to delete or correct them without a trace information. This will reduce the ability of attackers to influence the results of analytical research using information from these databases. Implementation scheme cloud- resources, obviously will rely on a combination Infrastructure as a Service (IaaS) – «infrastructure as a service» and Data as a Service (DaaS) – «data as a service», whether even a not very used variant of use is possible cloud-resource - Everything as a Service (EaaS) , «all as a service».

Another feature of the ISMP is that information on contamination may be evidence of the culprit's fault. For Art. 304, Chapter 4 of the Merchant Shipping Code of Ukraine [11] responsibility for damage to the water from pollution due to the discharge from the ship of oil or other substances harmful to human health or living resources of the sea is the owner of the vessel. A vessel carrying in bulk as cargo, more than 2 thousand tons of petroleum products must have a "certificate certifying that the liability of the ship-owner for damage caused by oil pollution is provided in accordance with Art. 309 of the Code of Merchant Shipping of Ukraine. The conditions and procedure for issuing, verifying and recognizing this certificate shall be established by the central executive body, which ensures the formation of state policy in the field of transport in accordance with Art. 3 of the Merchant Shipping Code of Ukraine » [11]. In certain circumstances, the said central authority, which provides such a certificate and monitors its availability, may make a party to the enforcement proceedings for damages. Accordingly, this central authority should be interested in the implementation of information and analytical support which, performing the functions of the

DSS was able to automatically analyze the presence or absence of such evidence and automatically notify the relevant officials. This adds to the importance of using DSS information as an evidence base and, accordingly, imposes requirements for its accumulation and storage.

Formation of a mathematical model of DSS. It is proposed to use a combination of two oriented graphs for DSS modeling. The first digraph ***G= (V, A)*** simulates a set of nodes V, each of which is an information database, for example, a database of the relevant line ministry. The set of arcs ***A*** satisfies the condition$\boldsymbol{A \in V \times V}$. We consider data transmission channels as arcs between nodes. By definition, in the general case$\boldsymbol{(v_i, v_j) \neq (v_j, v_i)}$. The magnitude of the flow of information is determined functionally$\boldsymbol{\gamma}$(a). When a node is not a database that has the ability to accumulate information, but is a transit node, it will comply with Kirchhoff's law. In accordance with this law$\boldsymbol{\sum \gamma_{inputs} = \sum \gamma_{outputs}}$, that is, the amount of input information per unit time must be equal to the amount of output information for all sources and drains.

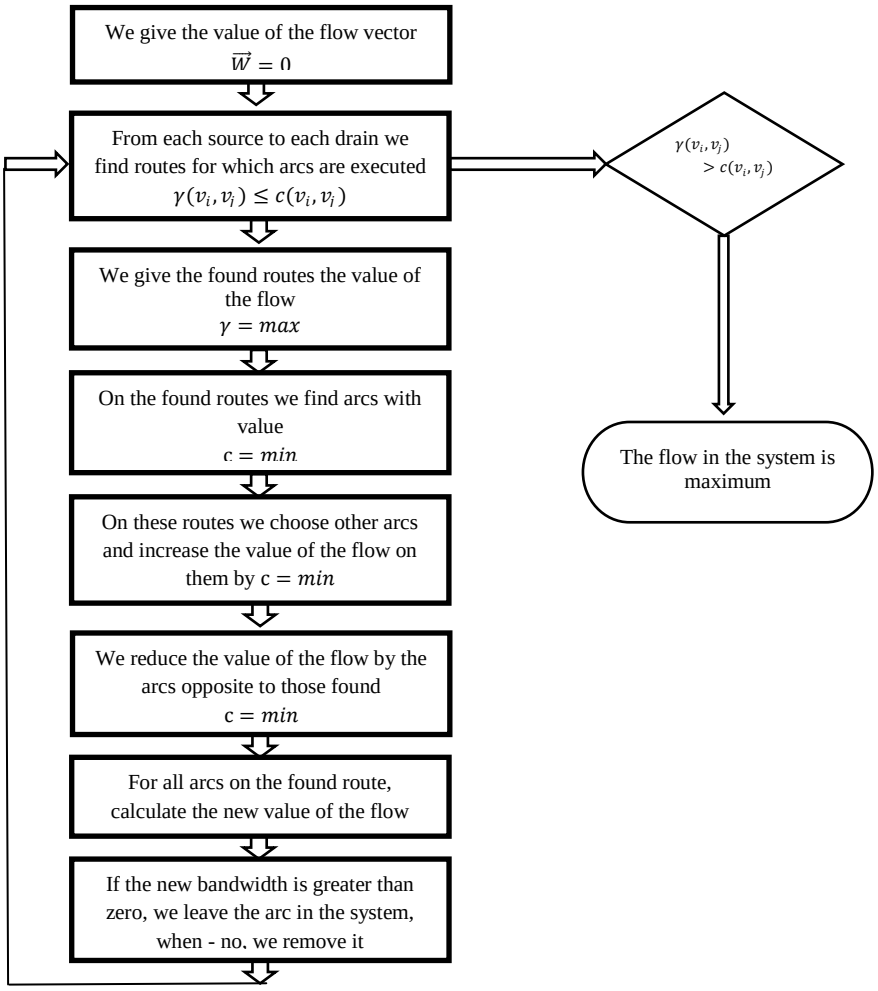

Fig. 1. Algorithm before the design check of the bandwidth of the routes of the information system for a dynamic version of information processing.

The second tentative graph is hierarchical, dissipative, which is a system of collecting information from primary sources and sending it to the appropriate nodes. Dissipative graph structures of information collection in this case to simplify their subsequent presentation can be considered as prefractal [12]. It is known that a fractal graph is defined as a structure that combines the properties of both a graph and a fractal. Thus, fractal graphs have all the features of a fractal: self-similarity, large-scale invariance, etc. Since fractal graphs are built on a hierarchical principle, the node of such a graph opens according to the next node in the hierarchy. In this case, the fractal graph with level disclosure will be prefractal. Then, for the prefractal graph $\boldsymbol{G_L = (V_L, A_L)}$ of the arc corresponding to the information channels combined with the information sources can be considered arcs of rank l. Both graphs are connected by corresponding incidence relations and both digraphs are weighted. That is, for each arc a$\boldsymbol{(v, u)}$ there is a corresponding value ***c(e)*** of the weight which is considered to be equal to the bandwidth of the information transmission channel between the nodes

connected by the specified arc. For data transfer operations in dynamic mode, we divide the array of the set of nodes $\boldsymbol{V}$ into subsets of nodes $\boldsymbol{S \in V}$, with the property $\mathbf{d}^{+} = \mathbf{0}$, and nodes $\boldsymbol{T} \in \boldsymbol{V}$ with property $\boldsymbol{d}^{-} = \mathbf{0}$. We identify them, respectively, with sources $\boldsymbol{s}$ and information flows $\boldsymbol{t}$. Thus, the information system will be formed by these digraphs with weight functionsc: $\boldsymbol{A} \rightarrow \boldsymbol{R}+$. And before the design application of Traffic Engineering methods will be implemented on the mentioned structure of combined graphs.

The considered DSS is intended for support and decision-making Users need such solutions the most in the most difficult moments - the presence of accidents, crises and more. But these moments are characterized by the fact that the information begins to flow to the relevant databases through existing channels with a surplus, characteristic of the dynamic change of all parameters in times of accidents and crises. Accordingly, at the same time, the number of information requests from users to obtain measures to minimize the effects of these crises is growing significantly.

This can lead to a significant slowdown in the work of the DSS, reducing its quality and devaluing its value. quality assurance, balancing and optimization of information transfer. Therefore, when designing DSS, it is proposed to introduce methods of load balancing of information transmission channels and traffic engineering. As the main criterion in Traffic Engineering for ISMP we offer a resource utilization factor. The highest resource utilization rate according to RFC 2702 «Requirements for Traffic Engineering Over MPLS» for all databases DSS must be maintained throughout the DSS at a minimum [13,14]. Then traffic problems will be minimized. The IETF's approach in formulating the general recommendations of Traffic Engineering (using MPLS) was to comply with the following requirements for the objective function - the utilization rate of the i-th resource $\mathbf{K_i}$ [13]:

$$\mathbf{min}(\mathbf{max}\,\mathbf{K_i}) \qquad (1)$$

We also offer another way to increase efficiency for ISMP. The task of Traffic Engineering for ISMP should be to find such a set of routes, when all the elements of the general matrix of efficiency criteria will not be greater than the specified value of the design value $\mathbf{K}_{max}$. For the practical implementation of this approach, we offer an algorithm built using the Ford-Fulkerson method [15], which is presented in Fig. 1. o do this, take into account the parameters of information packets, their frequency and availability, in addition to congested routes, also under loaded channels, finding alternative routes for information transmission and redistribution of traffic to a less congested channel, and less congested channel must meet the requirements of the shortest and optimal route. The presence of a backup route does not lead to a dramatic increase in the reliability of information transmission. To accomplish this task, you need to use multi-path routing with traffic distribution by route. As a result of the analysis it is established that it is impossible to solve the specified complex problem for use of the unified mathematical approach.

Regarding the evaluation of the efficiency of the information transfer process, two main characteristics must be taken into account: the maximum bandwidth of the system and the maximum delay in data transmission. The maximum bandwidth of the system is chosen as the maximum value on the set of minimum bandwidth of its sections. Under the section in this case we understand the division of nodes into two classes so that the source of the flow and its drain belong to different classes, and under the bandwidth of the section we understand the product of the bandwidth of those edges whose vertices belong to different classes.

Conclusions and perspectives of further research. Conservation and protection of the natural resource potential of the marine environment from pollution by ships has two main directions according to the two main mechanisms of pollution. The first mechanism of pollution is associated with man-made disasters and shipwrecks. The second mechanism is directly related to the functioning of the cargo transportation system. This leads to the existence of two mechanisms for managing the environmental and man-made safety of the marine environment, combined into a single system and requiring a single information and analytical support for the protection of the marine environment from pollution by ships. These mechanisms form the flow of information and modes of operation, which differ in almost everything - the volume per unit time, format and types of data, the urgency of providing information to consumers, and so on. Which, from the point of view of DSS design, puts forward special requirements to design of information transmission channels of the corresponding bandwidth.

The limited capabilities of the system of subsystem of information collection - environmental monitoring and compliance with environmental legislation by all actors in the field of maritime transport of goods. Today, monitoring is carried out by a number of institutions, but the effectiveness of their work is limited by the capabilities of outdated equipment, lack of qualified personnel and limited funding.

The presented article examines the features of the formation of a single information and analytical support for the protection of the marine environment, in particular, those that are due to the existing regulatory framework.

A mathematical apparatus for designing information transmission channels and ensuring efficient Traffic Engineering has been created. The approach to an estimation of efficiency of process of information transfer and as the basic criterion in Traffic Engineering for IAZZMS - a resource utilization factor. The algorithm is formalized before the design check of the bandwidth of the information system routes under the dynamic variant of information processing.

All this provides the necessary conditions for the formation of a single information and analytical support for the protection of the marine environment.

ЛІТЕРАТУРА

1. Матус, С.А., Левіна, Г.М., Карпюк ,Т.С., Денищик, О.Ю. (2019) Базове дослідження стану та напрямів розвитку екологічної політики України та перспектив посилення участі організацій громадянського суспільства у розробці та впровадженні політик, дружніх до довкілля. Аналітичний звіт. Фонд «Відродження». 117 с. URL: https://www.irf.ua/wp-content/uploads/2019/12/baseline-research_report_publishing-dec-2019.pdf
2. Жихарєва, В. В., Дубовик, Н. В., Наврозова, Ю. О. (2016) Підвищення ефективності діяльності та конкурентоспроможності підприємств морегоподарського комплексу України: монографія. Одеса : КУПРІЄНКО СВ, 2016. 239 с.
3. Охорона навколишнього середовища від забруднення нафтопродуктами (2015) / Шестопалов, О. В., Бахарєва, Г. Ю., Мамедова, О. О. та ін. Х. : НТУ «ХПІ», 116 р. URL: http://repository.kpi.kharkov.ua/bitstream/KhPI-Press/16796/1/Shestopalov_Okhorona_navkolyshnoho_2015.pdf
4. Стан забруднення природного середовища на території України Огляд стану забруднення навколишнього природного середовища на території України за даними спостережень гідрометеорологічних організацій у 2019 році. Київ: Центральна геофізична обсерваторія імені Б. Срезневського. URL: http://cgo-sreznevskyi.kyiv.ua/index.php?fn=u_zabrud&f=ukraine
5. Environmental Assessment and Recovery Priorities for Eastern Ukraine (2017). Organization for Security and Co-operation in Europe, Kyiv: VAITE, 88 p. URL:https://www.osce.org/project-coordinator-in-ukraine/362566
6. Звіт з аналізу навколишнього середовища (2016). Міжнародний банк реконструкції та розвитку/Світовий банк. URL: http://documents1.worldbank.org/curated/pt/589411470215950798/text/ACS16696-UKRAINIAN-PUBLIC-UkraineCountryEnvironmentalAnalysisUAweb.txt
7. Алексєєва, Є. (2019) Застосування національними судами положень Орхуської конвенції у справах, що стосуються процедури оцінки впливу на довкілля. *Міжнародний судовий форум : «Судовий захист природного довкілля та екологічних прав»*, 104-110. URL: http://epl.org.ua/wp-content/uploads/2019/12/Zbirnik_Eko_forum.pdf
8. Системи прогнозування перебігу надзвичайних ситуацій природного та техногенного характеру (2016). Розробки вчених Інституту проблем математичних машин і систем НАН України. Повідомлення НАН України. Київ. НАН України. URL: http://www.nas.gov.ua/UA/Messages/Pages/View.aspx?MessageID=2419
9. Дзюняк, Д. Ю. (2017) Інформаційна технологія оцінювання параметрів викидів речовин за даними оперативного моніторингу забруднення атмосферного повітря. Дисертація на здобуття наукового ступеня кандидата технічних наук. Вінниця. Вінницький національний технічний університет. 133 р. URL: https://itgip.org/wp-content/uploads/2017/03/%D0%94%D0%B8%D1%81%D0%B5%D1%80%D1%82%D0%B0%D1%86%D1%96%D1%8F-%D0%94%D0%B7%D1%8E%D0%BD%D1%8F%D0%BA-%D0%94.%D0%AE..pdf
10. Лобода, Ю.Г. (2014) Використання інформаційних технологій для захисту довкілля. Наукові праці, Одеська національна академія харчових технологій, 46, 1, 244-247. URL: http://journals.uran.ua/swonaft/article/download/40694/36976
11. Кодекс торговельного мореплавства України: за станом на 23 травня 1995 р. [Кодекс № 176/95-ВР]. *Відомості Верховної Ради України*. 1995. №№ 47, 48, 49, 50, 51, 52. 349 с. URL: https://zakon.rada.gov.ua/laws/main/176/95-%D0%B2%D1%80#Text

12. Кулаков, Ю. А., Воротніков, В. В., Гуменюк І. В. (2013) Анализ структуры телекоммуникационной сети путем представления ее топологии предфрактальным графом. *Вісник НТУУ «КПІ» Інформатика, управління та обчислювальна техніка*, 58, 68-72. http://it-visnyk.kpi.ua/wp-content/uploads/2014/07/58_09.pdf

13. Khoshbakht, M., Tajiki , M. M., Akbari, B. (2016) SDTE: Software Defined Traffic Engineering for Improving Data Center Network Utilization. *International Journal of Information & Communication Technology Research*, 8, 1, 15-21, URL: http://journal.itrc.ac.ir/article-1-73-en.pdf

14. Awduche, D., Malcolm, J., Agogbua, J.(1999) RFC2702: Requirements for Traffic Engineering Over MPLS1999 RFC, RFC Editor, United States, DOI:https://doi.org/10.17487/RFC2702 URL: https://www.rfc-editor.org/info/rfc2702

15. Myint Than Kyi, Lin Lin Naing (2018) Application of Ford-Fulkerson Algorithm to Maximum Flow in Water Distribution Pipeline Network, *International Journal of Scientific and Research Publications*, 8 , 12, 306-310. DOI:10.29322/IJSRP.8.12.2018.p8441

REFERENCE

1. Matus, S.A., Levina, H.M., Karpiuk ,T.S., Denyshchyk, O.Iu. (2019) Bazove doslidzhennia stanu ta napriamiv rozvytku ekolohichnoi polityky Ukrainy ta perspektyv posylennia uchasti orhanizatsii hromadianskoho suspilstva u rozrobtsi ta vprovadzhenni polityk, druzhnikh do dovkillia. Analitychnyi zvit. Fond «Vidrodzhennia».[Матус, С.А., Левіна, Г.М., Карпюк ,Т.С., Денищик, О.Ю. Базове дослідження стану та напрямів розвитку екологічної політики України та перспектив посилення участі організацій громадянського суспільства у розробці та впровадженні політик, дружніх до довкілля. 117 р. URL: https://www.irf.ua/wp-content/uploads/2019/12/baseline-research_report_publishing-dec-2019.pdf [in Ukrainian].

2. Zhykharieva, V. V., Dubovyk, N. V., Navrozova, Yu. O. (2016) Pidvyshchennia efektyvnosti diialnosti ta konkurentospromozhnosti pidpryiemstv morehopodarskoho kompleksu Ukrainy: monohrafiia. Odesa: KUPRIIENKO SV [Жихарєва, В. В., Дубовик, Н. В., Наврозова, Ю. О. Підвищення ефективності діяльності та конкурентоспроможності підприємств морегоподарського комплексу України: монографія] 239 р. [in Ukrainian].

3. Okhorona navkolyshnoho seredovyshcha vid zabrudnennia naftoproduktamy (2015) / Shestopalov, O. V., Bakharieva, H. Yu., Mamedova, O. O. ta in. Kh.: NTU «KhPI» [Охорона навколишнього середовища від забруднення нафтопродуктами / Шестопалов, О. В., Бахарєва, Г. Ю., Мамедова, О. О. та ін.] 116 р. URL: http://repository.kpi.kharkov.ua/bitstream/KhPI-Press/16796/1/Shestopalov_Okhorona_navkolyshnoho_2015.pdf [in Ukrainian].

4. Stan zabrudnennia pryrodnoho seredovyshcha na terytorii Ukrainy Ohliad stanu zabrudnennia navkolyshnoho pryrodnoho seredovyshcha na terytorii Ukrainy za danymy sposterezhen hidrometeorolohichnykh orhanizatsii u 2019 rotsi. Kyiv: Tsentralna heofizychna observatoriia imeni B. Sreznevskoho. [Стан забруднення природного середовища на території України Огляд стану забруднення навколишнього природного середовища на території України за даними спостережень гідрометеорологічних організацій у 2019 році. Київ: Центральна геофізична обсерваторія імені Б. Срезневського.] URL: http://cgo-sreznevskyi.kyiv.ua/index.php?fn=u_zabrud&f=ukraine [in Ukrainian].

5. Environmental Assessment and Recovery Priorities for Eastern Ukraine (2017). Organization for Security and Co-operation in Europe, Kyiv: VAITE, 88 p. URL:https://www.osce.org/project-coordinator-in-ukraine/362566 [in Ukrainian].

6. Environmental Analysis Report (2016). International Bank for Reconstruction and Development / World Bank. URL: http://documents1.worldbank.org/curated/pt/589411470215950798/text/ACS16696-UKRAINIAN-PUBLIC-UkraineCountryEnvironmentalAnalysisUAweb.txt [in English].

7. Aleksieieva, Ye. (2019) Zastosuvannia natsionalnymy sudamy polozhen Orkhuskoi konventsii u spravakh, shcho stosuiutsia protsedury otsinky vplyvu na dovkillia. *Mizhnarodnyi sudovyi forum: «Sudovyi zakhyst pryrodnoho dovkillia ta ekolohichnykh prav»* [Алексєєва, Є. Застосування національними судами положень Орхуської конвенції у справах, що стосуються процедури оцінки впливу на довкілля.] 104-110. URL: http://epl.org.ua/wp-content/uploads/2019/12/Zbirnik_Eko_forum.pdf [in Ukrainian]

8. Natural and man-made emergency forecasting systems (2016). Developments of scientists of the Institute of Problems of Mathematical Machines and Systems of the National Academy of Sciences of Ukraine. Report of the NAS of Ukraine. Kiev. NAS of Ukraine. URL: http://www.nas.gov.ua/UA/Messages/Pages/View.aspx?MessageID=2419 [in Ukrainian]

9. Dziuniak, D. Yu. (2017) Informatsiina tekhnolohiia otsiniuvannia parametriv vykydiv rechovyn za danymy operatyvnoho monitorynhu zabrudnennia atmosfernoho povitria. Dysertatsiia kandydata tekhnichnykh nauk. Vinnytsia. Vinnytskyi natsionalnyi tekhnichnyi universytet. [Дзюняк, Д. Ю. Інформаційна технологія оцінювання параметрів викидів речовин за даними оперативного моніторингу забруднення атмосферного повітря]. 133 p. URL: https://itgip.org/wp-content/uploads/2017/03/%D0%94%D0%B8%D1%81%D0%B5%D1%80%D1%82%D0%B0%D1%86%D1%96%D1%8F-%D0%94%D0%B7%D1%8E%D0%BD%D1%8F%D0%BA-%D0%94.%D0%AE..pdf [in Ukrainian].

10. Loboda, Yu.H. (2014) Vykorystannia informatsiinykh tekhnolohii dlia zakhystu dovkillia. *Naukovi pratsi, Odeska natsionalna akademiia kharchovykh tekhnolohii*, [Лобода, Ю.Г. Використання інформаційних технологій для захисту довкілля.] 46, 1, 244-247. URL: http://journals.uran.ua/swonaft/article/download/40694/36976 [in Ukrainian].

11. Codex of Merchant Shipping of Ukraine: as of May 23, 1995. [Кодекс № 176/95-ВР]. *Відомості Верховної Ради України*. 1995. №№ 47, 48, 49, 50, 51, 52. 349 с. URL: https://zakon.rada.gov.ua/laws/main/176/95-%D0%B2%D1%80#Text [in Ukrainian].

12. Kulakov, Yu. A., Vorotnikov, V. V., Humeniuk I. V. (2013) Analyz strukturы telekommunykatsyonnoi sety putem predstavlenyia ee topolohyy predfraktalnыm hrafom. *Visnyk NTUU «KPI» Informatyka, upravlinnia ta obchysliuvalna tekhnika*, [Кулаков, Ю. А., Воротніков, В. В., Гуменюк І. В. Анализ структуры телекоммуникационной сети путем представления ее топологии предфрактальным графом.] 58, 68-72. http://it-visnyk.kpi.ua/wp-content/uploads/2014/07/58_09.pdf [in Ukrainian].

13. Khoshbakht, M., Tajiki , M. M., Akbari, B. (2016) SDTE: Software Defined Traffic Engineering for Improving Data Center Network Utilization. *International Journal of Information & Communication Technology Research*, 8, 1, 15-21, URL: http://journal.itrc.ac.ir/article-1-73-en.pdf [in English]

14. Awduche, D., Malcolm, J., Agogbua, J.(1999) RFC2702: Requirements for Traffic Engineering Over MPLS1999 RFC, RFC Editor, United States, DOI:https://doi.org/10.17487/RFC2702 URL: https://www.rfc-editor.org/info/rfc2702 [in English].

15. Myint Than Kyi, Lin Lin Naing (2018) Application of Ford-Fulkerson Algorithm to Maximum Flow in Water Distribution Pipeline Network, *International Journal of Scientific and Research Publications*, 8 , 12, 306-310. DOI:10.29322/IJSRP.8.12.2018.p8441 [in English].