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AN IMPROVEMENT OF THE METHOD FOR ASSESSING THE EFFICIENCY OF THE METHODS OF PERFORMING TASKS BY THE NAVAL FORCES IN THE CONDITIONS OF HYBRID OPERATIONS

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The object of the research is the use of forces (troops) of the Naval Forces (Navy). The subject of the research is the process of evaluating the effectiveness of the use of Navy in various ways. An improved method for assessing the effectiveness of the ways of performing tasks by the forces (troops) of the Navy during the performance of the tasks of protecting the economic activity of the state at sea in the conditions of the enemy's hybrid actions is proposed. The method has the following sequence of actions:

– an input of initial data;

– calculation of the probability of a timely response to enemy actions;

– calculation of the probability of the enemy's refusal to act;

– calculation of the probability of ensuring the protection of objects conducting economic activity of the state at sea;

– calculation of the mathematical expectation of the number of objects that conduct economic activity at sea and will be protected by the Naval forces (troops);

– calculation of the protection degree of objects conducting economic activity at sea;

– calculation of the degree of decrease in the carrying capacity of ships (for tasks related to sea transportation);

– calculation of the mathematical expectation of the avoided loss of economic activity;

– determination of the protection degree of economic activity;

– determination of costs of material and technical resources;

– choosing the best (rational) way of using the Naval forces (troops) in accordance with the chosen criterion.

The novelty of the method consists in the use of an improved system of indicators for evaluating the effectiveness of the Navy's methods of performing tasks, taking into account the dependence of the amount of mediated damage caused by sea transportation on the actions of the enemy and taking into account the effect of the Navy's demonstration actions and the use of simulation tools on the effectiveness of task performance. The considered example showed a 25–40 % increase in assessment accuracy due to the consideration of additional conditions and factors

Keywords: use of the Naval Forces; protection of economic activity at sea; hybrid actions

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1. Introduction

Hybrid war is generally understood as military actions carried out by combining military, diplomatic, informational, economic and other ways to achieve political aims. The specificity of this combination is that each of the military and non-military methods of conducting a hybrid conflict is used for military purposes and is used as a weapon. Transformation into a weapon (weaponization) occurs not only in the media sphere. Such a functional combination within hybrid conflicts of heterogeneous phenomena and devices requires a complex analytical approach from representatives of various fields of knowledge [1–3].

The concept of hybrid war turned out to be theoretically and practically the most suitable for determining the specifics of the actions of the Russian Federation (RF), which is trying to achieve its political aims by combining military, quasi-military, diplomatic, informational, economic and other ways. The specificity of the Russian hybrid aggression against Ukraine lies not so much in the general methods of hybrid warfare, but in Russia's unconditional violation of the system of international legal agreements, the large scale of the damage caused and the significant duration of the conflict [3–5]. In addition to the above mentioned, it is necessary to note the intensive conduct of hybrid actions by the enemy in the maritime environment since 2014 in order to prevent Ukraine from conducting economic activities at sea.

It should be noted that with the beginning of the Russian Federation's full-scale aggression against Ukraine on February 24, 2022, the fulfillment of tasks related to the protection of the economic activity of the state at sea has not lost its relevance. A demonstrative example of the importance of their implementation is the provision of grain export by sea. The need to counter the enemy necessitates the implementation of appropriate measures for the planning and use of forces (troops) of the Naval Forces (Navy) to protect such

activities, which are not inherent in the classical conditions of conducting an armed struggle at sea. However, the existing scientific and method apparatus for evaluating the effectiveness of the use of forces (troops) of the Navy does not allow to estimate it adequately [5–7].

This determines the need to revise the approaches for evaluating the effectiveness of the use of forces (troops) of the Navy during the execution of the tasks of protecting the economic activity of the state at sea and emphasizes the relevance of the research.

That is why the aim of the research should be considered to be the improvement of the method for assessing the effectiveness of methods of performing tasks by the Naval forces (troops).

2. Literature review and problem statement

The authors would like to draw attention to the fact that hybrid actions at sea are an under-researched topic and quite closed to the general public. This, in turn, determines the limitation of scientific works in the specified direction and their generality.

The work [8] provided a general overview of approaches to conduct hybrid operations at sea. The main approaches to conduct a hybrid confrontation at sea in the course of recent local conflicts are considered. Vulnerable objects of maritime hybrid warfare have been identified: offshore oil and gas installations; large hydrocarbon installations; shipping terminals or pipelines; submarine cables and deep-sea drilling rigs. The attacks on the specified elements of economic activity of states can negatively affect further investments in the country or region taking into account the risk of impact on the environment. Countermeasures against hybrid threats at sea are proposed. At the same time, the proposed mechanisms are general and do not provide for a specific mechanism for counteracting them.

The work [9] presents an overview of hybrid actions of the Russian Federation in the Baltic Sea. The economic and energy threats of hybrid actions in the specified economic region are identified. A separate threat – the blockade of sea ports is highlighted. It is noted that in order to effectively counter hybrid threats, convoys of merchant ships should be opposed on their way between seaports, sea and air robotic platforms should be used. At the same time, the issues regarding the order of application of the specified forces and devices, and the evaluation of the effectiveness of countering hybrid challenges and threats remain unresolved.

The work [10] presents an analytical review of actions of the Russian Federation at sea. The analysis of the impact of hybrid actions on the geopolitical world order against the background of the conflict between the Russian Federation and NATO was carried out. According to the authors, the World Ocean will become the most likely environment for waging hybrid wars of a new type, since it is, in fact, a giant node of criticality with a division into sub-nodes on a geographical basis, each of which has its own characteristic features, properties, characteristics and regional decision making centers. The main types of hybrid warfare at sea are: naval proxy warfare, naval economic warfare, naval hybrid warfare and naval cyber warfare. Sea piracy (sea terrorism, transportation of narcotic substances), illegal migration and human trafficking are noted as a separate component of hybrid actions at sea. A variant of naval hybrid warfare is given. General recommendations for increasing the security of the Russian Federation at sea are given. At the same time, the issues of assessing the effectiveness of countermeasures at sea are not listed.

The work [11] considered the influence of hybrid actions of the Russian Federation on the policy of the European Union. An analysis of the economic, social, informational and political aspects of the destructive impact on the politics of the European Union as a result of the hybrid actions of the Russian Federation was carried out. Particular attention is paid to hybrid operations at sea. Attention is focused on the need to revise the mechanisms for the protection of economic activity both in the entire European Union and in individual countries. At the same time, the specific mechanisms of the destructive policy of the russian federation and the procedure for evaluating their effectiveness are not given.

The work [12] carried out an analysis of the hybrid war of the People's Republic of China in the South China Sea. The economic, energy, military, food and information components of the hybrid influence of the People's Republic of China in the China Sea are considered. The following mechanisms of countermeasures are proposed: military countermeasures by introducing a permanent military contingent into the sea; diplomatic and economic sanctions. However, the proposed approaches do not contain clear recommendations for countering hybrid impacts at sea.

The work [13] created a new analytical tool for the identification of the enemy's hybrid actions and analysis by researching the hybrid challenges in the Black Sea region related to the situation on the Zmiyiniy Island. The approach makes it possible to identify the ways to establish which of them could create the most catastrophic consequences for Romania's energy security and to assess the aggressor's progress in achieving the desired effect. The result of the research is a seven-step algorithm for identifying hybrid warfare. The specified approach should be used to identify the beginning of hybrid actions at sea with the aim of further determining the order of their neutralization.

The work [14] carried out an analysis of the hybrid actions of the Russian Federation at sea in the Russian-Ukrainian war. It was determined that in order to counteract hybrid actions at sea, the use of the forces and devices of the Navy is necessary.

The work [6] proposed a system of indicators for evaluating the effectiveness of the use of forces (troops) of the Navy during the performance of the specified tasks and provided the main mathematical dependencies. At the same time, the developed mathematical model of task performance contains mathematical dependencies for evaluating the effectiveness of the actions of only the naval personnel of the Navy. The considered methods of action of the enemy (illegal armed formations and pirates) do not correspond to the real methods of action used by the forces (troops) in the course of conducting hybrid operations. The question of causing indirect damage to the maritime economic activity and the impact of conducting preemptive (demonstration actions) by the forces (troops) of the Navy on the effectiveness of the tasks are not taken into account.

The work [7] proposed a method for evaluating the effectiveness of the use of forces (troops) of the Navy during the performance of the tasks of protecting economic activity at sea, which is based on the elements of the scientific and method apparatus considered in the work [6]. Taking into account the above mentioned, the specified method does not al-

low to make an adequate evaluation of the effectiveness of the use of forces (troops) of the Navy in the existing conditions.

For this purpose, it is proposed to improve the method for assessing the effectiveness of methods of task performance by the forces (troops) of the Navy during the performance of the tasks of protecting the economic activity of the state at sea in the conditions of hybrid actions of the enemy.

3. The aim and objectives of research

The aim of the research is to improve the method for assessing the effectiveness of methods of task performance by the forces (troops) of the Navy during the performance of the tasks of protecting the economic activity of the state at sea in the conditions of hybrid actions of the enemy. This will make it possible to develop software for intelligent decision making support systems in the interests of the combat management of the actions of troops (forces).

To achieve the aim, the following objectives were set:

– to determine the algorithm for the implementation of the method;

– to give an example of the application of the proposed method.

4. Research materials and methods

The problem, which is resolved in the research, is to increase the accuracy of the assessment of the effectiveness of the methods of performing the Navy in the conditions of hybrid operations. The object of the research is the use of forces (troops) of the Navy. The subject of the research is the process of evaluating the effectiveness of the use of the forces (troops) of the Navy in various ways in the course of performing the tasks of protecting the economic activity of the state at sea in the conditions of the enemy's hybrid actions.

The research is based on the theory of probability for assessing the impact of the enemy's hybrid actions on objects that carry out economic activities at sea and the effectiveness of neutralizing such impact by using the forces and devices of the Navy in various ways. The hardware of the research process is AMD Ryzen 5.

5. The results of the improvement of the method for evaluating the effectiveness of the methods of execution by the Naval Forces in the conditions of hybrid actions

5. 1. An algorithm for the implementation of the method for evaluating the effectiveness of the methods of execution by the Naval Forces in the conditions of hybrid actions

The improved method for assessing the effectiveness of the ways of performing tasks by the forces (troops) of the Navy during the performance of tasks of protecting the economic activity of the state at sea in the conditions of hybrid actions of the enemy consists of the following sequence of actions (Fig. 1, 2):

Step 1. Input of output data.

At this stage, output data is entered, which is necessary to determine the methods of performing tasks by the forces (troops) of the Navy:

– defined tasks, the composition of the enemy's forces, the capabilities and the expected nature of actions;

– the available composition, state and capabilities of their forces;

– physical and geographical conditions;

– restrictions on areas and the use of forces and devices in accordance with the requirements of international maritime and humanitarian law form input data for the calculation of partial indicators.

Step 2. Calculation of the probability of a timely response of the designated forces (troops) of the Navy to the actions of the enemy against objects conducting economic activity at sea.

The value of the probability of a timely response of certain forces (troops) of the Navy to enemy actions against objects conducting economic activity at sea is being calculated P_{TRi} by expression:

$$P_{TRi} = \begin{cases} P_{DTi}P_{SCi}, \text{if } t_{DDFi} < t_{DEFi}, \\ 0, \text{if } t_{DDFi} \geq t_{DEFi}, \end{cases} \quad (1)$$

where P_{DTi} is the probability of detection by a specified devices of the Navy performing the protection task of i-th object, forces and devices of the enemy at a given range (in a given area); P_{SCi} is the probability of successful countermeasures of the certain ways of the Navy performing the task of protection of i-th object, forces and devices of the enemy; t_{DDFi} is the time of deployment of a specified Navy method (the time from the moment of detection of enemy forces and devices to the moment the specified Navy occupies a position relative to i-th object, which provides countermeasures to the forces and devices of the enemy), hour; t_{DEFi} is the time of movement of the enemy's forces and devices to i-th object (the time from the moment of detection of enemy forces by the forces and devices of the Navy to the moment of impact on the object of protection with the aim of disrupting (obstructing) its functioning), hour.

According to the experience of the forces, the adversary may engage in the performance of tasks related to the prevention of economic activity at sea in the conditions of hybrid actions:

– surface forces (battleships, boats, in the future – unmanned attack robotic marine systems);

– air attack devices (attack UAV).

Taking into consideration that the probability of detecting enemy surface forces and air attack devices (AAD) are independent events, the value P_{DTi} can be determined by the expression:

$$P_{DTi} = P_{DTi}^{sh}P_{DTi}^{UAV}, \quad (2)$$

where P_{DTi}^{sh} is the probability of detection by a specified method of the Navy, performing the task of protection i-th object, the surface forces of the enemy, at a given range (in a specified area); where P_{DTi}^{UAV} is the probability of detection by a specified method of the Navy, performing the task of protection of i-th object, devices of air attack of the enemy at a given range (in a specified area).

The values P_{DTi}^{sh} and P_{DTi}^{UAV} depend on the tactical and technical characteristics of the available armament of the forces and devices of the Navy, which are involved in the performance of tasks.

According to the existing methods of evaluating the effectiveness of surface and air search for targets.

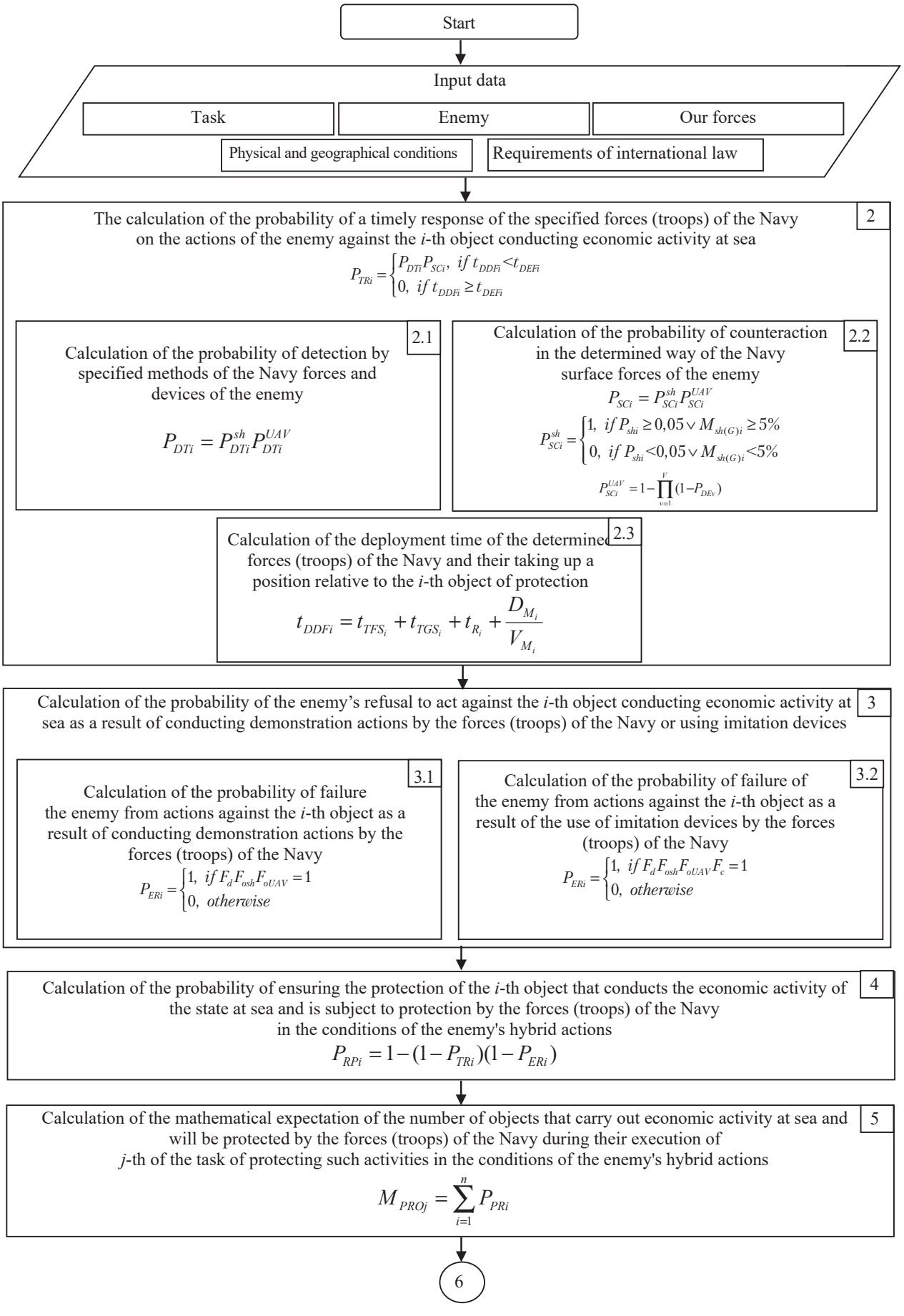

Fig. 1. Structural and logical scheme of the improved assessment method

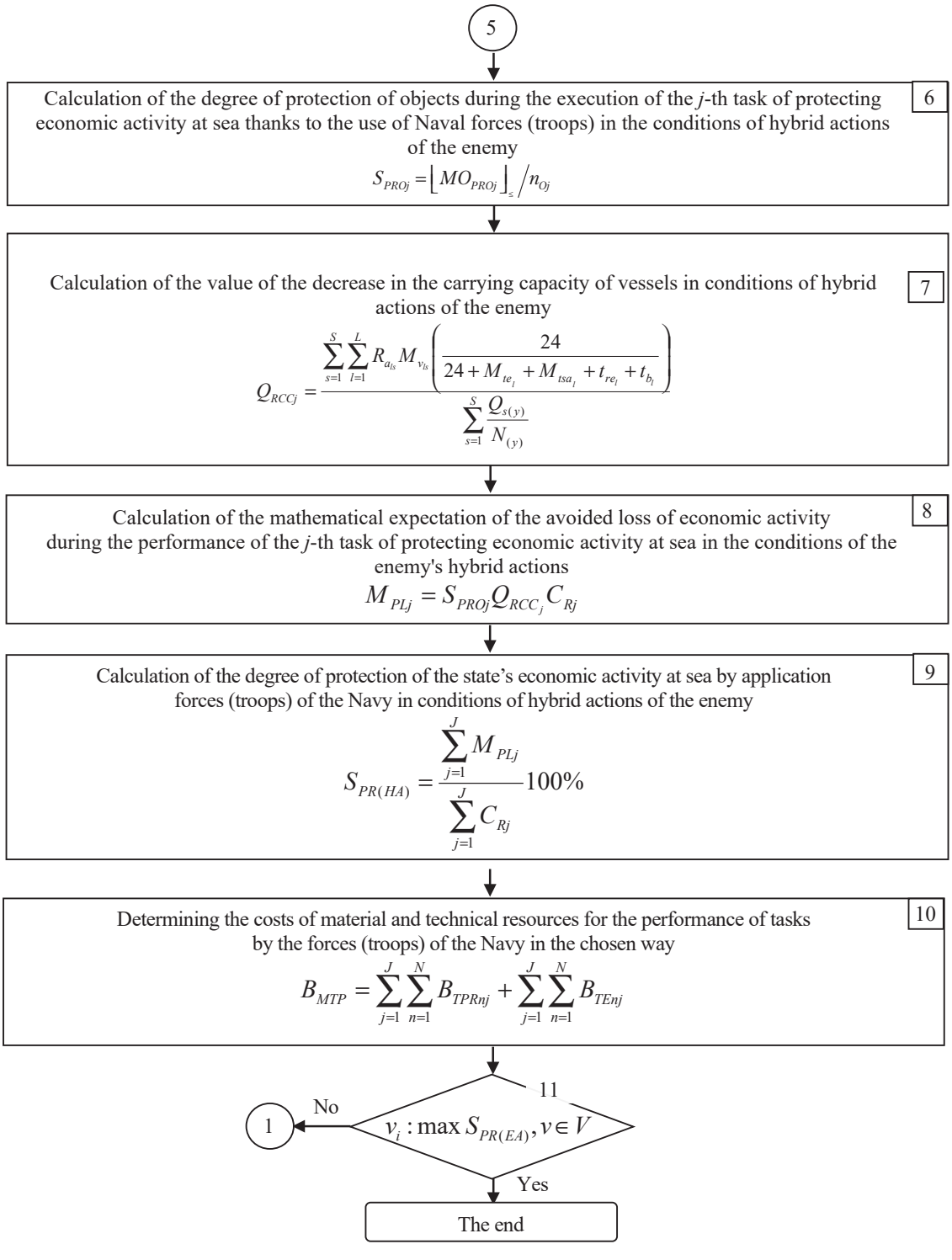

Fig. 2. Structural and logical scheme of the improved method for evaluating the effectiveness of the methods of performing tasks by the forces (troops) of the Naval Forces (continuation of Fig. 1)

Taking into consideration the probability of successfully countering the enemy's surface forces and air attack devices (AAD) are independent events, the value P_{SCi} can be determined by the expression:

$$P_{SCi} = P_{SCi}^{sh} P_{SCi}^{UAV}, \quad (3)$$

where P_{SCi}^{sh} is the probability of successful countermeasures of a specified method of the Navy, which are performing the task of protection of *i*-th object, against surface forces of the enemy; where P_{SCi}^{UAV} is the probability of successful countermeasures of a specified method of the Navy, which are performing the task of protection of *i*-th object, against the devices of air attack of the enemy.

While calculating the value P_{SCi}^{sh}, it is necessary to take into account the relevant experience of conducting hybrid operations at sea. Thus, all known cases of actions of surface forces to impede the activity of objects conducting economic activity at sea were carried out in the absence of their protection. In the case of demonstrating the presence of forces

protecting these objects and the determination of intentions to oppose the enemy, it refused such actions. This testifies to the inadmissibility of receiving losses by surface forces of the enemy in the conditions of hybrid operations. It determines the peculiarities of determining the amount of damage that the forces (troops) of the Navy must be able to inflict in order for it to refuse further actions. Experience shows that the enemy will refuse to perform tasks even while receiving (threat of receiving) «deterrent damage» – such dosed damage, in which it will lose confidence in the expediency of using forces to achieve the aim of actions. At the same time, there is no scientifically based approach to justifying the amount of deterrence damage in the course of conducting hybrid actions at sea. Therefore, its value is proposed to be determined in accordance with the practice of using the forces (troops) of the Navy during countering the surface forces of the enemy at sea in the conditions of hybrid operations.

The conducted analysis shows that the enemy refuses to perform tasks if it receives (threats to receive) the minimum possible damage, which is:

– for a single object – inflicting damage on it, «suppression» (inflicting such damage on it that leads to partial cessation (reduction of possibility) of functioning or complete cessation of functioning within a short period of time);

– for a group object – inflicting damage to it that meets the criterion no lower than «weakening» (destruction (disability, suppression) of a part (from 5 to 30 %).

The value P_{SCi}^{sh} is a probability value, but it acquires discrete values (0 or 1). P_{SCi}^{sh} depends on the ability of the forces (troops) of the Navy involved in the performance of the tasks of protecting the objects of economic activity to inflict «deterrent damage» on the surface forces of the enemy and will take the following values:

$$P_{SCi}^{sh} = \begin{cases} 1, \text{if } P_{shi} \geq 0.05 \vee M_{sh(G)i} \geq 5\,\%, \\ 0, \text{if } P_{shi} < 0.05 \vee M_{sh(G)i} < 5\,\%, \end{cases} \quad (4)$$

where P_{shi} is the probability of hitting a single surface target (ship, boat, vessel) that acts against the i-th object conducting economic activity at sea; $M_{sh(G)i}$ is the mathematical expectation of the number of affected main targets (objects) as part of a group target, which acts against the i-th object conducting economic activity at sea.

The value of t_{DDFi} can be calculated using the expression:

$$t_{DDFi} = t_{TFS_i} + t_{TGS_i} + t_{R_i} + \frac{D_{M_i}}{V_{M_i}}, \quad (5)$$

where t_{TFi} is the time of passing information from the moment of detection of enemy forces and devices to the command of the military management body that manages the forces (troops) of the Navy, hours; t_{TGS_i} is the time required to make a decision and set a task for the transfer of specified forces (troops) of the Navy to the i-th object, hours; t_{R_i} is the time of readiness of the determined forces (troops) of the Navy, assigned to protect the i-th object before the transition, hours; D_{M_i} is the distance of the transition of the determined forces (troops) of the Navy to the i-th object, along the shortest route, taking into account sea areas closed by the enemy or dangerous for navigation, miles; V_{M_i} is the speed of determined forces (troops) of the Navy on the way to the i-th object, nodes.

In the case of using several devices of the Navy to attack air targets, the value P_{SCi}^{UAV} can be calculated by the expression:

$$P_{SCi}^{UAV} = 1 - \prod_{v=1}^{V} \left(1 - P_{DEv}\right), \quad (6)$$

where P_{DEv} is the probability of damage to the enemy's attack UAV by the v-th devices of the Navy during the protection of the i-th object conducting economic activity at sea from the enemy's hybrid actions, $v = \overline{1,V}$.

Step 3. Calculation of the value of the probability of the enemy's refusal to take action against objects conducting economic activity at sea, as a result of the Navy's forces (troops) conducting demonstration actions and using imitation methods.

It is proposed to calculate the value of the probability of the enemy's refusal to take action against objects conducting economic activity at sea, as a result of the conduct of demonstration actions by the forces (troops) of the Navy and the use of P_{ERi} simulation tools, using the following expressions:

1. In case of conducting demonstration actions by the forces (troops) of the Navy:

$$P_{ERi} = \begin{cases} 1, \text{if } F_{di} F_{oshi} F_{oUAV_i} = 1, \\ 0 - \text{otherwise}, \end{cases} \quad (7)$$

where F_{di} is the function of compliance with the detection by the enemy of forces (troops) of the Navy, which are involved in conducting demonstration actions for the protection of the i-th object P_{d_i}; F_{oshi} is the function of compliance with the inability of the surface forces of the enemy (ship, boat, tactical group) to perform the task of hindering the activity of the i-th object without receiving deterrent P_{oshi} damage; F_{oUAV_i} is the function of matching the inability of the enemy's UAV attack to inflict a specified degree of damage on the i-th object, P_{oUAV_i}.

Taking into account the fact that in the course of carrying out tasks to prevent the conduct of economic activity at sea, the enemy conducts complex intelligence (land, sea, air, space), meaning P_{d_i} can be calculated by the expression:

$$P_{d_i} = 1 - \prod_{k=1}^{n_k} \left(1 - P_{d_{ik}}\right), \quad (8)$$

where $P_{d_{ik}}$ is the probability of detection by the k-th type of enemy reconnaissance of the forces and devices of the Navy, which are involved in the performance of the defense task i-th object that conducts economic activity at sea; n_k is the number of designated devices of the k-th type of intelligence, which the enemy uses.

The probability of the inability of the surface forces of the enemy (ship, boat, tactical group) to complete the task in terms of preventing the activity of the i-th object without them receiving deterrent damage, P_{oshi} can be calculated according to the expression:

$$P_{oshi} = 1 - P_{SCi}^{sh}. \quad (9)$$

The probability of the enemy's UAV attack being unable to hit the given degree of damage to the i-th object can be calculated by the expression:

$$F_{oUAV_i} = 1 - \left(1 - \prod_{v=1}^{V} \left(1 - P_{DEv}\right)\right), \quad (10)$$

where P_{Dev} is the probability of damage to the enemy's UAV attack by the v-th devices of the Navy during the protection

of the *i*-th object conducting economic activity at sea from the enemy's hybrid actions, $v=\overline{1,V}$.

Matching functions F_{di}, F_{oshi}, F_{0UAVi} take the value 1, if the values of the given probabilities satisfy the following values: $P_{d_i}\geq 0.9$; $P_{oshi}\leq 0.95$; $F_{oUAV_i}\leq 0.7$. If the specified threshold values are not met, then the specified compliance functions take the value 0, which means that the enemy will not refuse to perform the tasks of preventing the conduct of economic activity by the *i*-th object.

2. In the case of conducting the use of imitation devices by the forces (troops) of the Navy:

$$P_{ERi}=\begin{cases}1, \text{if } F_{di}F_{oshi}F_{oUAV_i}F_{c_i}=1,\\ 0-\text{otherwise},\end{cases} \quad (11)$$

F_{c_i} is the function of the conformity assessment by the enemy of the detected signs of the functioning of the false object, created to simulate the activities of the forces (troops) of the Navy for the protection of the *i*-th object in the course of conducting demonstration actions P_{c_i}.

Matching functions F_{di}, F_{osh_i}, F_{oUAV_i}, F_{c_i} take the value 1, if the values of the given probabilities satisfy the following values: $P_{d_i}\geq 0.9$; $P_{oshi}\leq 0.95$; $F_{oUAV_i}\leq 0.7$; $P_{c_i}\geq 0.9$. If the specified threshold values are not met, then the specified compliance functions take the value 0, which means that the enemy will not refuse to perform the tasks of preventing the conduct of economic activity by the *i*-th object.

Step 4. Calculation of the value of the probability of ensuring the protection of objects conducting the economic activity of the state at sea and subject to protection by the forces (troops) of the Navy.

Calculation of the value of the probability of ensuring the protection of objects that conduct the economic activity of the state at sea and are subject to protection by the forces (troops) of the Navy P_{PRi} can be done by the expression:

$$P_{RPi}=1-\left(1-P_{TRi}\right)\left(1-P_{ERi}\right). \quad (12)$$

Step 5. Calculation of the mathematical expectation of the number of objects that conduct economic activity at sea and will be protected by the forces (troops) of the Naval Forces.

Calculation of the value of the mathematical expectation of the number of objects that conduct economic activity at sea and will be protected by the forces (troops) of the Navy M_{PROj} can be carried out according to the expression [6]:

$$M_{PROj}=\sum_{i=1}^{n}P_{PRi}. \quad (13)$$

Step 6. Calculation of the value of the degree of protection of objects conducting economic activity at sea.

Calculation of the value of the degree of protection of objects conducting economic activity at sea S_{PROj} can be carried out according to the expression [6]:

$$S_{PROj}=\frac{\left\lfloor M_{PROj}\right\rfloor_s}{n_{Oj}}, \quad (14)$$

where n_{Oj} is the number of objects that carry out economic activities at sea and are the subject to protection by the forces (troops) of the Navy during their performance of the *j*-th task to protect such activities in the conditions of hybrid actions of the enemy.

Step 7. Calculation of the degree of reduction in the carrying capacity of ships on the routes of their movement in the maritime operational area (for tasks related to the protection of maritime transport).

The impact of the enemy's actions on the implementation of sea transportation in the conditions of hybrid operations at sea will be characterized by a decrease in the carrying capacity of ships along all (defined) recommended routes. For its determination, an indicator of the decrease in the carrying capacity of vessels on the recommended routes of vessel traffic in the maritime operational area during a defined period of time Q_{RCC} is proposed, the value of which can be determined by the formula:

$$Q_{RCC}=\frac{\sum_{s=1}^{S}M_{Q_{ha_s}}}{\sum_{s=1}^{S}Q_s}, \quad (15)$$

where $M_{Q_{ha_s}}$ is the mathematical expectation of the amount of cargo turnover of the *s*-th seaport, taking into account the actions of the enemy to prevent sea transportation, where $s=\overline{1,S}$, t; Q_s is the cargo traffic of the *s*-th seaport in the absence of enemy actions to prevent sea transportation, where $s=\overline{1,S}$, t; S is the number of seaports in the maritime operational zone (the area where the Navy carries out the tasks of protecting economic activity at sea).

The value of the partial indicator Q_s can be calculated by the expression:

$$Q_s=\frac{Q_{s(y)}t_{pt}}{N_{(y)}}, \quad (16)$$

where $Q_{s(y)}$ is the cargo turnover of the *s*-th sea port in the absence of enemy actions to prevent sea transportation during the calendar year, t; t_{pt} is the time during which the Navy forces are assigned the task of protecting sea transportation, days; $N_{(y)}$ is the number of days in the current calendar year.

An implementation of measures by the enemy in the conditions of hybrid actions to prevent the implementation of sea transportation leads to an increase in the time of movement of ships to ports (from ports). Then the expression for the definition $M_{Q_{ha_s}}$ must contain an appropriate coefficient that allows to take into account the specified influence of the enemy. In addition, the value $M_{Q_{ha_s}}$, it is proposed to count not as a whole for the *s*-th seaport, but as the sum of the cargo turnover of all recommended ways of movement of ships to it:

$$M_{Q_{ha_s}}=\sum_{l=1}^{L}R_{a_l}M_{v_l}t_{ptl}K_{ha_l}, \quad (17)$$

where R_{a_l} is the average carrying capacity of one vessel involved in sea transportation through the *s*-th seaport and moving to this port (from the port) along the *l*-th recommended route, where $l=\overline{1,L}$, t; M_{vl} is the mathematical expectation of the number of unaffected ships that are involved in sea transportation through the *s*-th seaport and move to this port (from the port) along the *l*-th recommended route per day, where $l=\overline{1,L}$; K_{ha_l} is the coefficient that takes into account the loss of time by ships on the passage along the *l*-th recommended route to the *s*-th seaport due to the actions of the enemy, where $l=\overline{1,L}$, is defined as a fraction of a unit; L is the number of recommended routes for ships to the *s*-th seaport; t_{pt_l} is the time during which the Navy forces are

assigned the task of protecting sea transportation along the l-th recommended route to the s-th seaport, days.

Taking into account the types of threats to ships in transit by sea and in seaports in the conditions of hybrid actions of the enemy, the importance M_{v_l} can be calculated by the expression:

$$M_{v_l} = n_l P_{mp_l} P_{usp_l}, \tag{18}$$

where n_l is the number of ships that carry out sea transportation through the s-th seaport and move to this port (from the port) on the l-th recommended route per day; P_{mp_l} is the probability that ships will not be hit by naval mine weapons while moving along the l-th recommended path; P_{usp_l} is the probability of damage to vessels moving along the l-th recommended route from the actions of underwater diversionary forces and devices (UDFD) in the port.

To create a mine hazard, the enemy can use sea floating mines on the routes of passage of ships and sea mines of other types on the app $P^r_{mp_l} = P^r_{smd_l} P^r_{asm_l}$, roach channels to ports, the value of P_{mpl} becomes:

$$P_{mp_l} = P^r_{mp_l} P^{ach}_{mp_l}, \tag{19}$$

where $P^r_{mp_l}$ is the probability of not being damaged by ships moving along the l-th recommended path during their movement to the approach channel to the port.

$P^{ach}_{mp_l}$ is the probability of not being hit by naval mine weapons of ships moving along the l-th recommended path during their movement along the approach channel to the port.

The value $P^r_{mp_l}$ can be calculated by the expression:

$$P^r_{mp_l} = P^r_{smd_l} P^r_{asm_l}, \tag{20}$$

where $P^r_{smd_l}$ is the probability of detection by vessels of sea floating mines while moving along the l-th recommended path; $P^r_{asm_l}$ is the probability of ships evading detected sea floating mines while moving along the l-th recommended path.

Taking into account the fact that the detection of floating sea mines on the ship's path involves a one-time inspection by the observer of its location and the speed of the mine is not equal to zero, the value $P^r_{smd_l}$ can be calculated by the expression:

$$P^r_{smd_l} = 1 - e^{-\frac{2D_{ol}V_{pcpl}t_{sl}}{S_{al}}}, \tag{21}$$

where D_{o_l} is the detection range of a sea floating mine while the ship is moving along the l-th recommended path, miles; V_{pcp_l} is the average speed of the relative movement of the ship and the sea floating mine while moving along the l-th recommended path, nodes; t_{s_l} is the time of survey by a vessel of the area for the purpose of detecting sea floating mines while moving along the l-th recommended route, hours; S_{a_l} is the area of the area surveyed during the movement of the vessel along the i-th recommended route, miles^2.

The value $P^r_{asm_l}$ is a probabilistic value, but it acquires discrete values (0 or 1) and depends on the ability of the ship to make a safe maneuver in time to avoid a sea floating mine and can be calculated by the expression:

$$P^r_{asm_l} = \begin{cases} 1, \text{if } q_t > \Delta q, \\ 0, \text{otherwise}, \end{cases} \tag{22}$$

where q_t is the turning angle of the vessel during evasion of a sea floating mine; Δq is the angle between the direction to the target and the set point of divergence with the sea floating mine.

The value of Δq can be calculated by the expression:

$$\Delta q = \arcsin \frac{R}{D_{nm}}, \tag{23}$$

where R is the distance of safe separation from a sea floating mine, kbt; D_{nm} is the distance to the sea floating mine, kbt.

The value of R can be calculated by the expression:

$$R = D_r + \Delta_l + V_{nm} t_l, \tag{24}$$

where D_r is the width of the response band of the sea floating mine to the physical fields of the ship, kbt; Δ_l is the marginal error of the relative position of the maneuvering vessel; V_{nm} is the speed of sea floating mine, high school; t_l is the reaction time from the moment of detection of a sea floating mine to the beginning of the maneuver of the vessel to avoid it, min.

The value of Δ_l can be calculated by the expression:

$$\Delta_l = 3\sqrt{\Delta^2_v + \Delta^2_{nm}}, \tag{25}$$

where Δ^2_v is the mean squared error of the ship's position; Δ^2_{nm} is the mean square error of the sea floating mine location.

The value $P^{ach}_{mp_l}$, the probability of not damaging ships while moving along the approach channel after conducting mine countermeasures by the Navy is equal to the given probability of detecting sea mines on the approaches to the ports by the Navy.

The value of P_{uspl}, the probability that vessels will not be damaged by the actions of the UDFD, can be implemented according to the mathematical relationship:

$$P_{usp_l} = 1 - \left(1 - P_{dsl}\right)^m, \tag{26}$$

where P_{ds_l} is the probability of detecting sabotage forces and devices of the enemy in the area of the seaport to which the ships are moving along the l-th recommended route, upon its one-time inspection by the designated forces of the Navy; m is the number of completed surveys of the district.

The value P_{ds_l} is calculated by the formula:

$$P_{ds_l} = \min\left\{P_{k_i} \frac{S_{g_l}}{S_{o_l}}; 1\right\}, \tag{27}$$

where P_{k_l} is the probability of detecting sabotage forces and devices of the enemy in the area to which the ships are moving along the l-th recommended path (while searching using technical search devices that are selected from the form and while using visual devices is 0.8); S_{g_l} is the area to which the vessels move along the l-th recommended route and which is surveyed by the designated forces of the Navy, m^2; S_{o_l} is the given area to which vessels move along the l-th recommended route and which is subject to survey, m^2.

The value of K_{hal}, which takes into account the loss of time by vessels during the passage, can be calculated by the expression:

$$K_{ha_l} = \frac{24}{24 + M_{te_l} + M_{tsa_l} + t_{re_l} + t_{b_l}}, \tag{28}$$

where M_{te_l} is the mathematical expectation of the time spent by vessels moving along the l-th recommended route through

areas dangerous for navigation due to floating mines, hours; M_{tsa_l} is the mathematical expectation of the time spent by ships, as a result of waiting for the Navy to carry out mine countermeasures in the approach channel to the seaport, during which the movement of merchant ships is not carried out, hours; t_{re_l} is the additional time spent by vessels to bypass sea areas temporarily closed to navigation or areas dangerous for navigation due to sea mines, while moving along the l-th recommended route, hours; t_{b_l} is the time during which ships are prohibited from moving to ports (from ports) along the l-th recommended route, hours.

The value M_{te_l} will be equal to the sum of the time of navigation twilight (the time when the safe movement of ships through areas dangerous for navigation due to sea mines is impossible). The second component of time is the mathematical expectation of the time that vessels will spend after the end of navigation twilight due to the need to reduce their speed in case of poor visibility due to weather conditions (fog, precipitation, etc.).

Considering the specified value M_{te_l} can be determined by the expression:

$$M_{te_l} = t_{d_l} + \left(\frac{D_l \left(V_{0_l} - V_{bw_l} \right)}{V_{0_l} V_{bw_l}} \right) P_{bw_l}, \quad (29)$$

where t_{d_l} is the time of navigation twilight, hours; D_l is the length of the route of the movement of vessels along the l-th recommended path through areas dangerous for navigation due to sea floating mines, miles; V_{0_l} is the speed of movement of ships along the l-th recommended route in the absence of mine danger, nodes; V_{bw_l} is the speed of movement of ships along the l-th recommended route in case of deterioration of visibility due to weather conditions, university; P_{bw_l} is the probability of deterioration of visibility on the route of the passage of vessels along the l-th recommended path due to weather conditions.

The value P_{bw_l}, the probability of deterioration of visibility on the route of passage of vessels due to weather conditions will depend on:

– meteorological characteristics of the area and taking into account the value of the average annual number of cloudy days (cloudiness of 8–10 points);

– the average annual frequency of fogs and the average annual number of days with precipitation.

To determine the value M_{tsa_l}, mathematical expectation of time, it is necessary to take into account the order of execution of relevant actions and measures (sequential, simultaneous).

Considering the specified value M_{tsa_l} with the consistent implementation of anti-mine actions and anti-sabotage measures can be determined by the expression:

$$M_{tsa_l} = M_{mc_l} + M_{ul_l}, \quad (30)$$

where M_{mc_l} is the mathematical expectation of the time required to conduct mine countermeasures on the approach channel to the seaport, along which vessels moving along the l-th recommended route enter the port (exit from the port) determined by the order of the Navy forces, hours; M_{ul_l} is the mathematical expectation of time for carrying out measures determined by the order of the Navy forces regarding the survey of the underwater part of hydrotechnical structures in the seaport area and the underwater part of the hulls of ships that were moving along the l-th recommended path, hour.

The value M_{tsa_l} with the simultaneous execution of actions and measures can be determined by the expression:

$$M_{tsa_l} = \max\left\{ M_{mc_l}; M_{ul_l} \right\}. \quad (31)$$

The value calculation M_{mc_l}, the mathematical expectation of time for conducting mine countermeasures by the Navy on the l-th approach path with a given probability of detecting sea mines (P_{mdi}=0.95) and the allocated force can be carried out according to the following mathematical dependencies:

– in case of search (destruction) of anchor mines:

$$M_{mc_l} = \frac{S_{\eta_l}}{W_l^b(t) N_{(G)l} P_{cr_l}}, \quad (32)$$

where S_{η_l} is the area of the approach channel to the seaport, along which vessels moving along the l-th recommended route enter the port (exit from the port), on which the search (destruction) of sea mines is carried out by a mine-clearing ship (a mine-clearing device, a mine-clearing trawler group), miles^2; W_l^a is the productivity of a mine countermeasures ship (mine countermeasures, mine counter trawl group) for searching and destroying anchor mines, miles^2/h; $N_{(G)l}$ is the number of anti-mine ships (mine anti-mine devices, anti-mine trawling groups) that carry out the task of finding (destroying) anchor mines; P_{cr_l} is the probability of combat effectiveness of anti-mine weapons of an anti-mine ship (mine anti-mine device, anti-mine trawl group);

– in case of search (destruction) of bottom mines:

$$M_{mc_l} = \frac{S_{\eta_l}}{W_l^b(t) N_{(G)l} P_{cr_l}}, \quad (33)$$

where W_l^b is productivity of a mine countermeasure ship (mine countermeasures, mine counter trawl group) for searching and destroying bottom mines, miles^2/h;

– in case of sequential search (destruction) of anchor and bottom mines:

$$M_{mc_l} = \frac{S_{\eta_l}}{\left(\frac{W_l^a W_l^b}{W_l^a + W_l^b} \right) N_{(G)l} P_{cr_l}}. \quad (34)$$

The value of magnitude P_{cr_l} can be determined by the expression:

$$P_{cr_l} = K_{cr_l} P_{tfo_l} P_{ua_l} P_{f_l}, \quad (35)$$

where K_{cr_l} is the coefficient of combat readiness of trawl, seeker; P_{tfo_l} is the probability of trouble-free operation of the trawl (seeker) during the implementation of mine countermeasures; P_{ua_l} is the probability of error-free actions of the personnel during the implementation of mine countermeasures; P_{f_l} is the probability of failure of the trawl (seeker) in the event of the explosion of one mine in the trawl (seeker).

Calculation M_{ul_l}, the mathematical expectation of time for carrying out measures determined by the order of the Navy forces regarding the survey of the underwater part of hydrotechnical structures in the seaport area and the underwater part of ship hulls is described:

$$M_{ul_l} = \frac{S_{ul_l} m}{N_{ul_l} w_{ul_l} v_{ul_l} P_{c_l}}, \quad (36)$$

where S_{ul_l} is the given area of the seaport, into which the ships move along the *l*-th recommended route and which is subject to inspection by the combat swimmers of the unit to fight against UDFD, m^2; *m* is the given frequency of surveying the water area of the seaport; N_{ul_i} is the number of groups of combat swimmers of the unit to fight against UDFD, which are involved in carrying out the tasks of surveying the water area of the seaport; w_{ul_i} is the width of the strip surveyed by one group of combat swimmers of the unit to fight against UDFD on one tack while surveying the water area of the seaport area, m; v_{ul_i} is the average search speed while surveying the water area of the seaport, m/min; P_{c_l} is the probability of combat effectiveness of anti-submarine and sabotage equipment.

In order to reduce the time for vessels to go around sea areas temporarily closed to navigation or areas dangerous for navigation due to sea mines while moving along the *l*-th recommended path, it is necessary to determine the most profitable (shortest route) of their movement D_{M_l}. In the future, it makes it possible to find meaning t_{re_l}, additional time spent by ships to bypass sea areas temporarily closed to navigation or areas dangerous for navigation due to sea mines while moving along the *l*-th recommended path, according to the following expression:

$$t_{re_l} = \begin{cases} \dfrac{D_{M_l} - D_{0l}}{V_{pr_l}}, \text{if } D_{M_l} > D_{0l}, \\ 0, \text{if } D_{M_l} \le D_{0l}, \end{cases} \quad (37)$$

where D_{Ml} is the length of the shortest route for vessels to bypass dangerous (potentially dangerous) sea areas in the maritime operational zone (the area where the Navy performs the tasks of protecting economic activity at sea) while moving along the *l*-th recommended path, miles; D_{0l} is the length of the route of the movement of vessels in the maritime operational zone while moving along the *l*-th recommended path in the absence of enemy actions to prevent maritime transport, miles; V_{pr_l} is the average speed of the movement of ships on the sea crossing along the *l*-th recommended route, nodes:

1. The value t_{b_l}, the time during which ships are prohibited from moving to ports (from ports) on the *l*-th route depends on the situation in the maritime operational zone at the moment.

Thus, taking into account (15)–(37), expression (14) will have the following form:

$$Q_{RCCj} = \frac{\sum_{s=1}^{S}\sum_{l=1}^{L} R_{a_{ls}} M_{v_{ls}} \left(\dfrac{24}{24 + M_{te_l} + M_{tsa_l} + t_{re_l} + t_{b_l}} \right)}{\sum_{s=1}^{S} \dfrac{Q_{s(y)}}{N_{(y)}}}. \quad (38)$$

Step 8. Calculation of the mathematical expectation of prevented damage to economic activity during the implementation of each task of protecting the economic activity of the state at sea.

Calculation of value M_{PLj} is calculated by the expression:

$$M_{PLj} = S_{PROj} Q_{RCC_j} C_{Rj}, \quad (39)$$

where C_{Rj} is the value of the economic activity that was subject to protection during the performance of the *j*-th task of protecting economic activity at sea by using the forces (troops) of the Navy, $j = \overline{1, J}$.

The value of the partial indicator Q_{RCC_j} for the tasks of the forces (troops) of the Navy, not related to the protection of sea transportation, is equal to 1.

Step 9. Determination of the degree of protection of the economic activity of the state at sea by the use of forces (troops) of the Navy in conditions of hybrid actions of the enemy by the chosen method.

Determination of the degree of protection of the economic activity of the state at sea by the use of forces (troops) of the Navy in the conditions of hybrid actions of the enemy is calculated according to the expression:

$$S_{PR(\ A)} = \frac{\sum_{j=1}^{J} M_{PLj}}{\sum_{j=1}^{J} C_{Rj}} 100\,\%, \quad (40)$$

where $S_{PR(HA)}$ is the degree of protection of the economic activity of the state at sea by the use of the forces (troops) of the Navy in the conditions of hybrid actions of the enemy, measured from 0 (the task is not completed) to 1 or 100 % (the task is completed in full, within the set time); M_{PLj} is the mathematical expectation of avoided damage to economic activity during the performance of the *j*-th task of protecting economic activity at sea by the use of Navy forces (troops), $j = \overline{1, J}$.

Step 10. Determination of costs of material and technical resources for the execution of tasks by the forces (troops) of the Navy in the chosen way.

2. Determination of costs of material and technical resources for the execution of tasks for the execution of tasks by the forces (troops) of the Navy by the chosen method of B_{MTP}, can be determined by the formula:

$$B_{MTP} = \sum_{j=1}^{J}\sum_{n=1}^{N} B_{TPRnj} + \sum_{j=1}^{J}\sum_{n=1}^{N} B_{TEnj}, \quad (41)$$

where B_{TPRij} is the consumption material and technical resources of the *n*-th ship (aircraft, unmanned aerial vehicle, unmanned surface vehicle, etc.) during the *j*-th task of protecting the economic activity of the state at sea in conditions of hybrid actions of the enemy, $n = \overline{1, N}$, $j = \overline{1, J}$, calculation units; B_{TEij} is the expenditure of material and technical resources to support the *n*-th ship during the *j*-th task of protecting the economic activity of the state at sea in the conditions of hybrid actions of the enemy, where $n = \overline{1, N}$, $j = \overline{1, J}$, calculation units.

Step 11. Choosing the best (rational) method of using the forces (troops) of the Navy in accordance with the selected criterion.

After defining the $S_{PR(HA)}$ values of the various ways of performing tasks by the forces (troops) of the Navy, which were considered during the planning of their implementation, one of them is chosen that meets the selected criterion.

Using efficiency criterion, it is expedient to determine the maximum level of the values of the degree of protection of the economic activity of the state at sea by the use of the forces (troops) of the Navy in the conditions of hybrid actions of the enemy:

$$v_r : \max S_{PR(HA)}, v \in R, \quad (42)$$

where v_r is a certain *r*-th option chosen from the set *R* of acceptable variants of the composition and order of use of forces (troops) of the Navy during the execution of the tasks

of protection of the economic activity of the state at sea, which are under consideration, in the conditions of hybrid actions of the enemy; R is a set of options for the composition and order of use of forces (troops) of the Navy during the implementation of the tasks of protecting the economic activity of the state at sea, which are under consideration, in the conditions of hybrid actions of the enemy.

The limitations are the amount of resources (allocated for tasks or such that does not exceed the value of the economic activity subject to protection).

The end of algorithm.

5. 2. An example of the application of the proposed improved method while evaluating the effectiveness of execution by the forces (troops) of the Naval Forces

An improved method for evaluating the effectiveness of the methods of task performance by the forces (troops) of the Naval Forces during the performance of the tasks of protecting the economic activity of the state at sea in the conditions of the enemy's hybrid actions is proposed.

A comparison of the proposed method with works [6, 7] was carried out. The task to be solved was to assess the effectiveness of the Navy's forces (troops) in carrying out navigation protection tasks in the Black Sea operational zone in «hybrid» conditions during the functioning of the «grain corridor» (Fig. 3).

Fig. 3. Scheme of operation of the «grain corridor»

The period from 01.01.2023 to 31.01.2023 was chosen for simulation. The raw data is taken into account according to agreements between Ukraine, Turkey and the UN, Turkey, the UN and the Russian Federation regarding the safe export of agricultural products from Black Sea Ukrainian ports. It is taken into account requirements of Memorandum regarding navigation along the approach corridor to the ports of Ukraine (Chornomorsk, Odesa, Pivdennyi):

– a grain is exported from three designated ports: Odesa, Chornomorsk and Pivdenniy;

– the movement of vessels to/from all designated ports is carried out along the designated «grain corridor»;

– it is assumed that the enemy does not damage commercial ships and ports involved in the functioning of the «grain corridor»;

– the humanitarian corridor is controlled remotely by the parties, therefore warships, planes and unmanned aerial vehicles cannot approach the «grain corridor» closer than the distance agreed by the Joint Coordination Center.

Having calculated the value of the degree of protection of the economic activity of the state at sea by the use of forces (troops) of the Navy in accordance with the works [6, 7], taking into account the specified conditions, a value of 100 % was obtained, which does not correspond to the real situation.

At the same time, while conducting a comparative assessment with works [6, 7], it was established that the proposed method additionally takes into account:

– the presence of a mine hazard on shipping routes due to the enemy's use of floating sea mines;

– the actions of underwater diversionary forces and devices on the approaches to ports in the water area of the ports;

– hydrometeorological conditions of the area, etc.

– causing indirect damage to sea transportation through the enemy's creation of special conditions on the shipping routes.

Taking into account the specified additional conditions and factors of the specified factors in the proposed method allowed:

– to take into account the infliction of indirect damage by the enemy by sea transportation;

– to determine the value of the mathematical expectation of the avoided loss and, subsequently, the value of the main indicator, the degree of protection of the economic activity of the state at sea by the use of the forces (troops) of the Navy in the conditions of the enemy's hybrid actions.

A comparison of the method from the works [6, 7] according to the criterion of mathematical expectation of the avoided loss of economic activity at sea showed that the profit from the proposed approach is from 25 to 40 %.

6. Discussion of the results of improving the assessment method of the effectiveness of the ways of performing tasks by the Naval Forces

It is advisable to use the mentioned research at the stage of planning the protection of the maritime economic zone of the state using the forces and devices of the Navy. At the stage of planning measures to protect the maritime economic zone of the state, the proposed approach allows:

– to calculate the necessary number of forces and devices of the Navy, which must be involved in the protection of the maritime economic zone;

– to determine the possible damage to the state economy from the enemy's hybrid actions at sea;

– to plan measures to protect the maritime economic zone of the state using the forces and devices of the Navy.

The limitations of the research are the need to have an initial database on the state of the naval operations zones, the need to take into account the time delay for the collection and proving of information from intelligence sources.

The advantages of the proposed method are the following:

– additionally to take into account the factors that affect the adequacy and reliability of the evaluation of the effectiveness of the ways of performing tasks by the forces (troops) of the Navy;

– to take into account the dependence of the amount of mediated damage by sea transportation on the actions of the enemy (15)–(18);

– to take into account the influence of demonstration actions by the forces (troops) of the Navy and the use of simulation tools on the effectiveness of task performance (Step 3, expressions (6)–(11));

– to take into account the existing threats to objects conducting economic activity at sea in the conditions of hybrid actions, in particular, the enemy's use of attack unmanned aerial vehicles and unmanned maritime robotic systems (Step 2).

The main advantages of the proposed method are:

– it has an extensive system of evaluation indicators, which allows to fully and comprehensively evaluate the effectiveness of the use of forces and devices of the Navy;

– unambiguity of the received assessment of the economic security of the state at sea;

– the possibility of working with different sizes;

– the possibility of adding new indicators to the system.

The disadvantages of the proposed method include:

– the failure to take into account the reliability of input data;

– the lack of possibility of training databases on the state of economic security of the region.

This method will allow:

– to determine the composition of the forces and devices of the Navy to ensure the economic security of the region;

– to determine the effectiveness of countering hybrid threats by the forces and devices of the Navy.

The research is a further development of the researches on the assessment of the security of the maritime economic zone of the state [6, 7], taking into account the works [8–16].

It is advisable to use the proposed method to solve the problems of developing methods of performing tasks and choosing the optimal method of using the forces (troops) of the Naval Forces under the given conditions of the situation in the course of operational planning.

The directions of further research should be aimed at expanding the system of indicators for evaluating the effectiveness of the use of forces (troops) of the Military and Naval Forces in countering hybrid threats at sea.

7. Conclusions

1. The algorithm for the implementation of the method for evaluating the effectiveness of the methods of task performance by the forces (troops) of the Naval Forces during the performance of the tasks of protecting the economic activity of the state at sea in the conditions of hybrid actions of the enemy has been defined, which allows:

– additionally to take into account the factors that affect the adequacy and reliability of the evaluation of the effectiveness of the ways of performing tasks by the forces (troops) of the Navy;

– to take into account the dependence of the amount of mediated damage by sea transportation on the actions of the enemy;

– to take into account the impact of conducting demonstration actions by the forces (troops) of the Navy and the use of simulation tools on the effectiveness of task performance;

– to take into account the existing threats to objects conducting economic activity at sea in the conditions of hybrid actions, in particular, the enemy's use of attack unmanned aerial vehicles and unmanned maritime robotic systems.

2. An example of the use of the proposed improved method is given. The evaluation of effectiveness was carried out during the execution by the forces (troops) of the Naval Forces of navigation protection tasks in the Black Sea operational zone in «hybrid» conditions (evaluation of the effectiveness of the use of forces (troops) of the Navy during the functioning of the «grain corridor». The specified example showed an increase in the accuracy of the assessment by 25–40 % due to consideration of additional conditions and factors.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, including financial, personal, authorship or any other, that could affect the research and its results presented in this article.

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