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Применение подводного дрона в ходе исследования тел утопленников: научный обзор

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АННОТАЦИЯ

В статье сообщается об эффективности беспилотного подводного аппарата (подводный дрон) в поиске утонувших в водоёмах людей, а также влияние подводного дрона на производство судебно-медицинской экспертизы при утоплении.
В работе рассматриваются нормы законодательства, регулирующие порядок применения подводного дрона в процессе криминалистического обеспечения расследований преступлений. Подробно разбираются нормы законодательства, регулирующие порядок применения научно-технических средств в криминалистике, научные публикации исследователей в области судебно-медицинской экспертизы. Проведён SWOT-анализ применения подводного дрона с целью повышения качества расследования преступлений. По результатам исследования определены положительные и отрицательные стороны применения подводного дрона в следственных действиях.
По результатам обобщения научных трудов, анализа применения научно-технических средств в деятельности правоохранительных органов зарубежных стран авторы предлагают использование подводного дрона для осмотра трупа в воде. Подводный дрон может достичь недоступных для человека мест, и помочь выявить ключевые детали преступления. В ходе расследования преступлений по фактам утопления они играют особую роль, так как позволяют проанализировать состояние тела жертвы без необходимости поднятия его на поверхность, что облегчает дальнейшее расследование.

Ключевые слова: вода; осмотр; подводный дрон; труп; утопленник; экспертиза.

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Use of an underwater drone during the study of drowned bodies: a review

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ABSTRACT

This article describes the effectiveness of an unmanned underwater vehicle (underwater drone) in searching for drowned people in reservoirs and the impact of an underwater drone on the production of forensic medical examination in drowning.

The article considers the norms of legislation that regulate the procedure for using an underwater drone in the criminalistic support of crime investigations.

This study considered the norms of legislation that regulate the use of scientific and technical means in criminology and scientific publications of researchers in the field of forensic medical examination. A SWOT analysis of the use of an underwater drone to improve the quality of crime investigation was performed. The results of the study revealed the positive and negative aspects of the use of an underwater drone in investigations.

Based on the results of generalization of scientific papers and analysis of the use of scientific and technical means in the activities of law enforcement agencies in foreign countries, the use of an underwater drone for examining corpses in water was proposed. An underwater drone can reach places inaccessible to humans and help identify key details of the crime. During investigation of drowning crimes, underwater drones enables the analysis of the condition of the victim's body without bringing it to the surface, which facilitates further investigation.

Keywords: water; inspection; underwater drone; corpse; drowned man; expertise.

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在溺水者尸体检查中使用水下无人机：科学综述

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摘要

本文章介绍无人潜航器（水下无人机）在寻找水体中溺水者方面的有效性，以及水下无人机对溺水法医学鉴定的影响。

本文中研究了在刑事侦查的支持过程中应用水下无人机的立法规则。本文详细分析了关于在犯罪侦查学中应用科技手段的立法规则、法医学鉴定领域研究人员的科学出版物。作者对应用水下无人机来提高刑事侦查质量进行了SWOT分析。根据研究结果，确定了在侦查行为中使用水下无人机的优缺点。

根据对科学研究进行归纳总结的结果，以及对外国执法机构在活动中使用科技手段的分析，作者提出了使用水下无人机检查水中尸体的建议。水下无人机可以到达人类无法到达的地方，有助于确定犯罪的关键细节。它们在调查溺水犯罪中发挥着特殊作用。可以利用无人机来分析受害者尸体的状况，而无需将其从水里拽上来。这有助于进一步调查。

关键词：水；检查；水下无人机；尸体；溺水者；鉴定。

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BACKGROUND

Current information technologies enable to rapidly and efficiently resolve issues in all spheres of human life. The limitless possibilities of information technologies create avenues for searching, processing, and exchanging information; enable the maximum automation of production activities; enhance labor efficiency and people's safety; and simplify business management (including government, law enforcement, and other services). A notable advancement in forensic technology is the development of unmanned aerial and underwater drones specifically designed to collect and process information across various inhabited environments relevant to forensic scenarios.

Modern technology advances have improved the use of aerial and underwater drones, expanding the possibilities of their use, primarily in forensic medicine. However, in forensic medical science, the capabilities of underwater drones are limited. Further research is needed to address key issues related to the utilization of underwater drones in forensic medical practice. Thus, the objective of this study was to provide a comprehensive overview of the use of underwater drones in forensic medicine and to propose a methodology for using these drones as a scientific and technical tool for examining a corpse discovered in water.

In this study, expertise refers to the application of scientific and technical achievements in the activities of law enforcement agencies, particularly in criminal procedure. Examination involves a study commissioned and carried out in accordance with legal norms, utilizing specialized knowledge in science, technology, art, or craft. The resulting conclusion serves as evidence in legal proceedings. [1]. Furthermore, in the investigation and disclosure of criminal offenses involving human victims, such as murder, expertise is an integral part of criminal procedure. Examination is a method of determining the trial's circumstances through the application of modern scientific achievements during the investigation [2], for example, an unmanned underwater vehicle.

The current study discusses aspects of examining a corpse displaying signs of drowning without the need to remove it from the water or the incident location. When scientific and technical inspections are conducted, the individual functions of the unmanned underwater drone should be considered. The examination results indicate that employing underwater drones for conducting forensic medical examinations in cases of drowning proves to be an effective and promising method for developing this field.

SCIENTIFIC UNDERSTANDING OF UNMANNED UNDERWATER DRONES

Underwater drones emerge as an innovative tool for conducting forensic medical examinations on corpses displaying signs of drowning. Such unmanned underwater devices are beneficial for effectively and accurately determining cause of death, especially in cases where access to the body is challenging or impossible. Underwater drones possess high maneuverability and are capable of operating at great depths, which enables the search and examination of drowned human bodies in water environments of varying complexity[1].

The necessity of employing underwater drones for forensic medical examinations in drowning cases stems from several factors. First, drowning is a common cause of death among individuals engaging in underwater activities for various purposes. The factors contributing to such tragedies are varied and should be identified to prevent such cases. Thus, an examination of drowning incidents becomes critical to elucidate the surrounding circumstances and the causes of death. Second, employing an underwater drone facilitates efficient search operations and retrieval of corpses from water bodies, mitigating the risks posed to forensic scientists, rescuers, and divers. Moreover, utilizing underwater drones reduces the likelihood of inflicting damage to drowned bodies during transportation to the shore. Additionally, these drones have specialized equipment capable of recording vital data concerning the condition of drowned individuals (i.e., temperature, water level, and other parameters). This data is useful in determining the time and circumstances of death, as well as other medical aspects related to drowning incidents.

Death in water is commonly presumed to be accidental drowning, potentially preventing the prompt detection of signs of violence and other crucial evidence available at the scene of the crime [3]. Numerous submergence-related deaths occur due to unintentional drowning in natural aquatic environments or as a result of natural disasters like floods and hurricanes. Additionally, fatalities involving bodies discovered in water may entail signs of accidental, suicidal, or homicidal injuries, as well as underlying medical conditions leading to death.

Understanding the diagnosis of fatal drowning, characteristics of the environment in which the drowning occurred, and accurately determining the time of death and post-mortem interval are crucial for advancing forensic medical investigations into water-related fatalities. Ongoing analysis and dissemination of data obtained from investigations into water-related deaths help determine their impact on public health and safety. This, in turn, informs decisions regarding resource allocation and funding aimed at preventing similar deaths [3].

In the current era of rapid digital advancements with widespread impact on all aspects of public life, including the sphere of law and order, thoughtful consideration is critical before introducing modern scientific and technological

[1] TechSphere2 [Internet]. "How underwater drones are changing the rules of search and rescue operations [May 20, 2023]. Access mode: https://ts2.com.pl/ru/how-underwater-drones-change-the-rules-by/#gsc.tab=0. Date of access: 01/15/2024.

innovations. Given the increasing reliance on technology and automated tools in contemporary law enforcement, studying this topic is paramount.

Regarding law enforcement agency activities, it could take several months for scuba divers to locate drowned individuals. This poses challenges in conducting timely forensic medical examinations. However, employing underwater drones for locating drowned individuals accelerates the discovery process, enabling prompt examination of bodily injuries. In underwater crime scenes, the pretrial investigation can be extremely complex, and its outcome is greatly influenced by the limitations of available equipment and procedures.

EFFICIENCY OF USING AN UNDERWATER DRONE IN FORENSIC MEDICAL EXAMINATION OF A CORPSE FOUND IN WATER

Establishing factors contributing to drowning

The primary issue in forensic medical examinations of corpses recovered from water is determining the contributing factors to drowning. Drowning is defined as death resulting from mechanical asphyxia due to closure of the respiratory tract by water. In drowning, the body is not necessarily completely immersed; immersion of only the head or part of it in water with the closure of the airways (e.g., in a state of alcoholic intoxication, during an epileptic seizure) is sufficient [4].

Regarding type of death, drowning can be classified as accidental, suicidal, or homicidal. Criminals often use bodies of water as disposal sites for corpses or body parts. Within forensic medical practice, instances arise where drowning is initially presumed as the cause of death before autopsy. However, upon examination of the corpse, no signs of drowning are evident, indicating that the individual's death in the water may have occurred due to another cause. Various factors can contribute to death in water, associated with a person entering or remaining in water [5].

Forensic medical examinations of corpses suspected to be involved in criminal activities are conducted based on the reasoned decision of the investigator i.e., the person conducting the pretrial investigation. These examinations, performed by experts with specialized scientific knowledge, aim to clarify circumstances relevant to the case[2]. In drowning cases, the forensic medical examination should address the following questions frequently posed by investigators:

- What was the cause of death?
- Was the death due to drowning or other causes?
- Under what conditions did the drowning occur, and what factors contributed to the drowning?
- How long was the human corpse present in water?
- If death was not due to drowning, what was its cause?
- If there are bodily injuries on the corpse, what are their nature and location?
- What are the mechanisms of formation of bodily injuries? Were they received during life or after death?
- What was the prescription of death coming? How much time elapsed from death to the corpse examination?
- What diseases were detected during examination of the corpse?
- How much alcohol (drugs) did the victim take shortly before his death?
- What is the probability of drowning in certain water reservoirs?

Condition of the corpse found in the water environment

The criminal prosecution body primarily examines the duration of the corpse's immersion in water, determined by the degree of skin swelling and the development of putrefaction. Putrefaction processes are influenced by factors such as the time of year, water temperature, reservoir depth, and water quality. According to scientific research, within 3–6 h of submersion, the fingertips develop wrinkled and pale skin. After 2 days, the skin on the extremities (palms and soles) becomes pale and wrinkled. On days 5–8, these changes extend to the dorsum of the hands, resulting in wrinkled, swollen, and whitish skin (washerwoman's hand). After 8–15 days, (sometimes later), the epidermis, along with the nails, easily separates from the hands owing to the "glove of death," giving them a sleek appearance. By the end of the week 2, the hair can be easily detached and washed off. Corpses removed from water tend to putrefy at an accelerated rate. If a corpse remains submerged for 4–5 days, signs of injuries sustained during life may be entirely lost[3] [6, 7]. In cases where the body is nearly or completely devoid of skin (before skeletonization) due to exposure to high temperatures and/or aquatic organisms, forensic anthropologists may get involved to identify and evaluate taphonomic changes [8].

In forensic medical examination, an important procedural document prepared by the investigative authority is the inspection report of the incident scene. The protocol should include the temperature of the air and water, water flow mobility and speed, reservoir depth, corpse position in the water, and method of corpse removal from the water. Additionally, the report should describe the examination of the corpse (the presence or absence of objects holding the

[2] Criminal Procedure Code of the Republic of Kazakhstan dated July 4, 2014, no. 231-V ZRK. Access mode: https://adilet.zan.kz/rus/docs/K1400000231. Date of access: 01/15/2024.

[3] Nonprofit partnership "European Bureau of Forensic Experts" [Internet]. "Drowning in water, forensic medicine". Access mode: https://euro-sudexpert.ru/utoplenie-v-vode-sudebnaya-meditsina/. Date of access: 01/15/2024.

body on the surface of water or contributing to its immersion and clothing and its damage, skin color, presence of bodily injuries, environment). It should also document any seized objects considered as material evidence[4]. Unawareness of the circumstances preceding death puts the expert in a difficult position when deciding the question of its cause, as a result of which, some deaths in water may be attributed to drowning, although morphological signs are inadequate [5]. Insufficient expertise among forensic experts may result in distorted examination results, thereby misleading other participants involved in the process [9].

Inspection of the incident location and the corpse in the water environment

Each body recovered from the water should undergo on-site examination by the investigator, i.e., the person conducting the pretrial investigation, to prevent distortion of information over time. The examination helps detect signs of violence that indicate to the investigator about the need for further action and gather crucial evidence. During the discovery of the corpse and prior to moving the body, any observed wounds should be recorded, since injuries can occur while transporting the body over rough terrain [3]. Underwater drones play a vital role in capturing accurate data and preserving the scene's integrity before the corpse's removal from the water, enabling a clear reconstruction of the incident.

Notably, a forensic expert, in accordance with the rules for the organization and conduct of forensic examinations and research in forensic examination agencies (cl. 381)[5], is involved as a specialist in the forensic medicine field to participate in the examination of a corpse at the place of its discovery (incident)[6]. Moreover, according to the articles of regulatory legal acts of Russia (Part 6 of Art. 164)[7] and Kazakhstan (Part 3 of Art. 197)[8] , technical means and various detection methods, recording, and seizure of traces of crime and material evidence can be used during investigative actions [2]. According to the requirements of criminal procedure legislation, an expert in the field of forensic medicine can be involved as a specialist in the inspection of the crime scene and the corpse.

Prompt and high-quality inspection of the incident scene and the corpse at the place of its discovery and data obtained by the doctor during the examination of the corpse help the investigator understand the essence of the event (crime), place and time of its commission, nature and mechanism of the damage formation on the corpse, and other circumstances. The established circumstances of the inspection and other data are of key importance in cases of extremely grievous crimes (murders), since the data obtained enables the investigator to create versions of the event and plan further investigative actions aimed at solving it. Incompetent examination of the corpse and incorrect documentation of the results of this examination can significantly complicate the further work of the investigator and cause serious errors during the investigation of this incident and subsequent forensic medical examination of the corpse.

When removing a corpse from the water and subsequently examining it, caution should be exercised not to damage physical evidence or add to the body damage, which could lead to erroneous conclusions. In most drowning cases, forensic pathologists and investigators cannot see the actual scene of the incident, but can only see human remains and objects associated with the body or crime, and only when recovered by diving personnel. To complete the crime scene description, forensic medical scientists and investigators rely on images and documentation provided by divers. In these cases, accurate underwater photography and video recording of the crime scene become necessary to capture a visual record of the crime scene that can be analyzed or studied later [10]. Owing to the use of scientific and technical means, the possibilities of proving are expanded; thus, the process of proving becomes "transparent, visual, and its results are more convincing" [11], the evidence base is strengthened because of the reliability of the evidence, and the nature of its reliability increases.

When examining the incident scene by an investigator or engaged forensic medical expert, for some reason, some circumstances or objects at the incident scene may be omitted. Additionally, during a forensic medical examination, a water sample taken from the scene of an incident may not coincide with the water extracted from the lungs of a corpse. In such cases (insufficiency or unsuitability of the materials submitted for examination), the expert submits a petition to the body (person) that appointed the examination for the need to provide additional materials within the period established by law[9]; this may be the collection of water from the incident scene for identification with water extracted from the corpse lungs or inspection of the incident scene

[4] Ibid.

[5] Order of the Minister of Justice of the Republic of Kazakhstan dated April 27, 2017, no. 484 "On approval of the Rules for the organization and conduct of forensic examinations and research in forensic examination agencies." Registered with the Ministry of Justice of the Republic of Kazakhstan on May 26, 2017, no. 15180. Access mode: https://adilet.zan.kz/rus/docs/V1700015180. Date of access: 01/15/2024.

[6] Criminal Procedure Code of the Republic of Kazakhstan dated July 4, 2014 No. 231-V ZRK. Art. 220 "General rules for inspection". Access mode: https://adilet.zan.kz/rus/docs/K1400000231. Date of access: 01/15/2024.

[7] Criminal Procedure Code of the Russian Federation (as amended on December 25, 2023). Access mode: https://docs.cntd.ru/document/901802257/titles?ysclid=lsacytrvaj302734585. Date of access: 01/15/2024.

[8] Criminal Procedure Code of the Republic of Kazakhstan dated July 4, 2014, no. 231-V ZRK. Access mode: https://adilet.zan.kz/rus/docs/K1400000231. Date of access: 01/15/2024.

[9] Order of the Minister of Justice of the Republic of Kazakhstan dated April 27, 2017, no. 484 "On approval of the Rules for the organization and conduct of forensic examinations and research in forensic examination bodies" (cl. 10). Registered with the Ministry of Justice of the Republic of Kazakhstan on May 26, 2017, no. 15180. Access mode: https://adilet.zan.kz/rus/docs/V1700015180. Date of access: 01/15/2024.

or the place where the corpse was found. In both cases, the use of an unmanned underwater drone is beneficial for resolving the issue promptly, since the device can be used for a safe and efficient inspection of the corpse at the discovery site. Moreover, underwater drones equipped with a water sampling function can take material from the depths of the reservoir where the corpse was found.

Thus, the use of underwater drones for forensic examination of a corpse has several advantages over traditional methods. According to a study by Paba et al. [10], accurate underwater photography and video recording of crime scenes is warranted to obtain visual records of the incident location that can be analyzed or used as evidence.

Material evidence as an objective means of establishing the truth

One of the sources in the judicial process is material evidence, i.e., items that are related to the incident and help reveal its circumstances. Various items taken from the scene of an incident become physical evidence if they are formalized according to certain rules in accordance with the requirements of criminal procedure legislation, i.e., investigative reports. Physical evidence is an objective means of establishing the truth and plays a significant role; sometimes it can be the only evidence that helps resolve the complex tasks facing investigative and judicial authorities in establishing the event of a crime. In several cases, physical evidence acquires significance for the investigation and court only after special studies diverse in nature, in which experts of different specializations are involved.

Criminal procedural legislation regulates certain procedures and methods for collecting material evidence, selecting material, and sending it for research in a laboratory. The collection of material evidence includes ensuring and establishing the authenticity of material evidence while precluding the possibility of forgery or substitution. In particular, Russian laws provide for the presence of witnesses during judicial and investigative actions related to the collection of material evidence (Art. 60 of the Code of Criminal Procedure of Russia[10]); in Kazakhstan, the inspection is performed using scientific and technical means of recording the results, and the mandatory participation of witnesses is provided for in the case of inspection of a residential premises (Art. 220 of the Code of Criminal Procedure of the Republic of Kazakhstan[11]). Items that are crucial as physical evidence are examined by the investigator and can be confiscated and sent for examination. According to the law, each piece of evidence should be assessed from the standpoint of relevance, admissibility, and reliability[12]. The relevant documents provide descriptions of evidences and indicates where and under what circumstances they were found and why they were seized. The description of the items should be supplemented with photographs that are attached to the relevant procedural document.

The use of an underwater drone at the scene of an incident or at the site where a corpse is found allows for an inspection of the corpse and its surroundings in the aquatic environment, recording all objects located at the scene and near the corpse. In recent years, photography, video recording, remote sensing, and artificial intelligence have been widely used in various environments to provide evidence in a wide range of investigations. Experts can obtain video footages and photographs of the corpse with a high degree of detail, which helps with subsequent data analysis. However, some disadvantages of using such technology should be noted. Underwater drones require a certain level of training and operator skill to be used effectively when inspecting a crime scene and corpse at the location of its discovery. In case of errors or inept operation of the underwater vehicle, collected data may not be accurate enough or even damaged.

Considering that a comprehensive approach to the use of unmanned underwater vehicles for the development and improvement of the legal process has not yet been developed in Kazakhstan (owing to lack of legal grounds and practical basis for underwater drone use and the materials they collect during investigations and forensic medical examinations), we conducted a SWOT analysis that revealed the predominance of the strengths of using this technology in the activities of the judicial system (Table 1). In particular, side-scan sonar and other acoustic imaging technologies (Fig. 1) have become valuable tools for detecting underwater targets, especially for first responders and law enforcement authorities.

CONCLUSION

Thus, the use of underwater drones for forensic medical examinations of drowned corpses, encompassing search and retrieval operations from water bodies, presents a promising and effective approach in advancing this area of research. Forensic assessments in drowning cases play a crucial role in both legal and medical responses, offering answers to grieving families and contributing to public safety measures. The value of such assessments remains critical to the understanding, prevention, and management of drowning accidents.

Underwater drones facilitate a more accurate and detailed examination of drowned bodies, aiding in determining causes of death and incident circumstances. Using remote sensing

[10] Criminal Procedure Code of the Russian Federation dated December 18, 2001, N 174-FZ (as amended on December 25, 2023). Access mode: https://www.consultant.ru/document/cons_doc_LAW_34481/?ysclid=lsa74lie65331418026. Date of access: 01/15/2024.

[11] Criminal Procedure Code of the Republic of Kazakhstan dated July 4, 2014, no. 231-V ZRK. Access mode: https://adilet.zan.kz/rus/docs/K1400000231. Date of access: 01/15/2024.

[12] Ibid.

Table 1. SWOT analysis of the use of an unmanned underwater vehicle

Strengths	Weaknesses
1. The possibility to search and detect drowned bodies in places inaccessible to humans. 2. Removing corpses from water bodies without the risk to lives of rescuers and divers. 3. Reduces significantly the time spent to search for bodies and improves localization accuracy. 4. The ability to record videos and photographs underwater, which facilitates the subsequent work of forensic medical experts. 5. The device can be used to determine the cause of death by examining the body of a drowned person at the incident location. 6. Available technology for investigation and forensics. 7. Increasing the responsiveness of obtaining information. 8. Possibility of using an underwater drone under conditions of limited visibility	1. High cost of equipment 2. Lack of trained specialists 3. Lack of statutory instruments governing the use of unmanned underwater vehicles
Opportunities	
1. Development of scientific and technical means in judicial practice 2. Expanding the possibilities in judicial investigation	
Threats	
1. Use of equipment in judicial and investigative practice with low technical characteristics 2. Possible problems with communication stability or data transfer, especially when working at great depths	

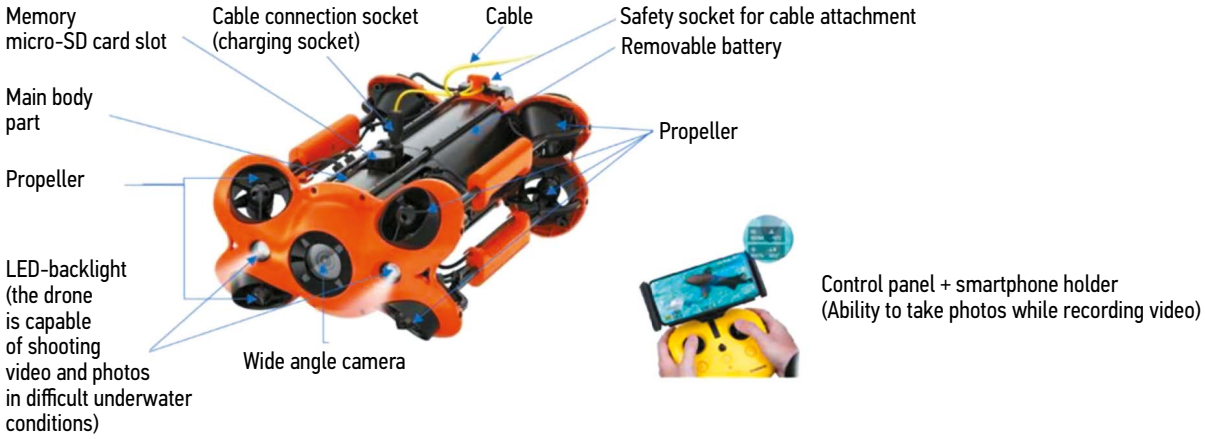

Fig. 1. Structural elements of an unmanned underwater vehicle.

techniques, data can be collected without direct physical interaction with the underwater environment, including from challenging or dangerous locations. Owing to their maneuverability and ability to respond quickly to changes in the hydrological situation, underwater drones significantly reduce examination durations. Moreover, they mitigate risks to the lives of rescuers, divers, law enforcement officers, and experts typically involved in manual operations.

The use of an underwater drone in the forensic medical examination of a corpse discovered in water is critical for improving the quality and efficiency of the investigation.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

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