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SCIENTIFIC DIVING IN NATURAL SCIENCES

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ABSTRACT

Scientific diving is increasingly being used for numerous studies. Moreover, this form of diving allows for the conduction of interdisciplinary research. The current nomenclature of this type of dive is defined as scuba diving to collect information to support science by using diving techniques. Underwater research is particularly important in the natural sciences where it allows for the non-invasive observations of fauna and flora of aquatic ecosystems in their natural environment. At the same time, the use of diving for scientific purposes avoids mistakes made in random sampling, which is related to the use of classical sampling methods. As a result, such diving is crucial in systematic, ecological and behavioural analysis. Nevertheless, dive techniques, however versatile, require optimisation, separate study and systematisation, depending on the type of research conducted. This article is an attempt to present an outline of the topic, to systematise basic concepts in presenting the principles of legal regulations in Poland and abroad..
Keywords: scientific diving, professional diving, underwater works, equipment for underwater research.

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INTRODUCTION

Diving as a form of professional activity developed in several independent directions. The most popular were military diving and commercial diving, related to the performance of industrial underwater works, or for the purposes of underwater tourism and recreation. At the same time, quite independently, a standardised diving system has been developed for scientific purposes, which uses similar ideological assumptions for working under the surface of the water [1]. Nowadays there is an increased interest of scientists in underwater research techniques [2]. The current HSE (*Health and Safety Executive*) nomenclature in the United Kingdom is a type of diving performed by scientists-naturalists, defined as diving in order to collect information serving broadly understood science or supporting the idea of science using diving techniques.

Underwater archeology is another type of diving as a scientific activity. This field has been in strong development since the last century [3]. The purpose of underwater archaeology is to search for and also to excavate artifacts or to take inventory of objects of historical significance. It should be emphasised that the use of this type of diving contributed to saving many artefacts resting on the bottoms of freshwater reservoirs [4]. The positions included in the study were not affected or destroyed.

In the United States, the idea of research using diving was initiated before World War II. A pioneer who introduced classes in the field of ecology of coral reefs at coral universities, using diving equipment, and the author of some unique research, was Charles William Beebe [5]. This trend originated from the need to explore the underwater world on various levels. Researchers wanted to reach the places of interest underneath the surface of the water and to observe, analyse or take samples *in situ*. All of them wanted to go beyond the familiar methodical framework of research [6].

It was observed that tests carried out using diving techniques allowed the analysis that was conducted to be completed in a more scientific manner – compared to random sampling from the surface, with the use of standard tools (e.g. hamon grab, bottom grabs). The non-invasive impact of such research on the natural environment is also important, as such methods greatly limit the accidental destruction of biocenoses. What's more, the very observation of the object under the surface of the water can bring valuable scientific data [1,7]. In addition, there are natural phenomena or organisms that are impossible to observe and identify without the participation of a diver, e.g. coral reef fish. Places that are difficult to access are also of interest, as exemplified by the rock caverns lying deep beneath the surface of the water [8,9].

As we can see, scientific diving is a very good tool for exploring hard-to-reach and isolated places. Work in such places as flooded caves allow us to get to know early preeminent species unknown to science [10]. Examples are shown in fig. 1 where the diver explores samples of cave crustaceans so far unknown to science.

Determining exactly what underwater research has been carried out by divers in the past is difficult to determine. Many works have not been published or the exact methodology of work has not been determined, other projects were clearly popular science. Numerous diving scientists using diving equipment and underwater cameras have archived many phenomena and also identified the presence of various species of aquatic organisms. Another example is fig. 2 where we see a diver taking samples of a vertical wall from an object at the bottom of the Baltic Sea.

Scientific diving combines diving methods known from various activities, both professional and recreational. Most often however, it is based on basic or slightly developed recreational diving equipment. However, though the general public's perception of the types of dives typically carried out by scientists is that of divers descending to clean the walls of an aquarium or to make video documentation of objects used in scienceThere are research programmes that use closed-circuit diving apparatuses, as well as diving helmets – equipment which is perhaps more recognisable as being from a more advanced form of exploration of the underwater world.

That said, all work related to the construction, use of dangerous tools or technologies are beyond the scope of scientific diving, advanced underwater research often being performed by professional divers who cooperate with scientists through CCTV equipment (live view) or personal supervision over the activities performed. Due to the fact that scientific research often requires the synthesis of several fields of science, to bring about innovative results, and gaining experience, both in narrow scientific fields and in advanced diving, requires years of education and training. Therefore,in the training programs of professional diving courses, topics such as research methodology or underwater photography are covered, so that divers can carry out these activities under the direct supervision of non-scientists, with no need for scientists to be present,. There are definitely no articles at the scientific level about the work methodology of divers and the applied solutions in procedures. One can get an impression that the subject of research dives in the natural sciences was avoided and to some extent controversial due to the existing legal regulations in Poland.

SCIENTIFIC DIVING IN POLAND

The subject matter among Polish researchers is also current, as evidenced by the increasing number of published scientific papers describing the mentioned issue. For example, a historical sketch of the "Diving in Tatra Mountains" was elaborated - the study covered mountain ecosystems [11]. Another example is the work of showing the history of diving in polar research [12].

In Poland, scientific diving was initially associated with the activities of several people, then it was developed and improved in some scientific institutions or underwater research clubs affiliated with universities. The beginning of diving, in order to carry out underwater tests, is related to the activity of prof. Roman Wojtusiak from the Department of Zoopsychology and Animal Ethology at the Jagiellonian University. In 1935, he commissioned an underwater helmet (open type, modeled on Beebe's helmet), supplied with air from the surface by means of a pump. In 1936 he made a test dive wearing this helmet near the Hel harbor, then he conducted biological observations in the Puck Bay region [13,14]. In addition, he performed a series of tests in Poland and Yugoslavia. His research "overtook the era" and is permanently

inscribed in the global development of scientific diving.

The scientific units that have built on the achievements of the Polish scientific diving trend include the Polish Academy of Sciences in Sopot, the University of Gdańsk or Gdańsk University of Technology. The underwater works carried out by the given units can be described as diving for scientific purposes. Mainly they were faunistic and floristic observations involved in the collection of samples, as well as the implementation of experiments and the installation of underwater scientific measuring equipment.

The next unit performing diving for scientific purposes is the Central Maritime Museum in Gdańsk, which carried out research work on dozens of wrecks lying in the Baltic Sea. Maintaining the subject of archaeology, the dynamically operating units in this field are: The Department of Underwater Archaeology at the University of Nicolaus Copernicus in Toruń or the Institute of Archaeology of the University of Warsaw, each training staff in the specialisation of underwater archaeology. This topic certainly requires a separate study by specialists. It should be mentioned, however, that outstanding Polish scientists have contributed to numerous discoveries in the field of underwater archaeology on a global scale [15].

For a long time, Polish legislators have not defined scientific diving, citing the Act of October 17, 2003 on underwater works (Journal of Laws No. 199 of November 24, item 1936) or other legal acts since repealed. In the case of natural sciences, it was classified as a recreational dive. In turn, the work of the diving archaeologist was described as underwater work. Some attempts to systematise the terminology were made after 2014, but they assumed the nature of exemptions rather than the correct, precise solutions.

The aforementioned vagaries however require additional explanation, because according to the Act of 17 October 2003 on underwater works, scientific diving was classed as professional diving. It was only the Act of 9 May 2014 on facilitating access to certain regulated professions that excluded scientific diving from professional diving by stating: "The Act does not apply to [...] scuba diving for research purposes organised by universities and research institutes. "

A project is currently underway to unify and standardise scientific diving in Europe - ESDP (*European Scientific Diving Panel*). In addition, the project is designed to enable the performance of research works that are in the implementation phase by "young researchers". Qualification levels were selected and ESD (*European Scientific Diver*) and AESD (*Advanced European Scientific Diver*) courses were offered to selected units. In addition to symposia-conferences, ESD also organises meetings. National regulations of European countries were collected and systematised. According to their data from 2011, there are no regulations regarding research diving in Poland.

SCIENTIFIC DIVING IN THE WORLD

World standardisation and occupational health and safety organisations provide two categories: commercial diving and scientific. However the differences between these dive categories are significant. In contrast to professional diving, the information obtained for scientific purposes must be universal (and, if possible, published) and should not have the character of commercial information.

In addition, you cannot use "heavy" work tools during scientific diving. The HSE also defines the distance from the shore, where research is carried out, introducing the concept of *offshore*. In *offshore* conditions, research work must be carried out only by professional divers with appropriate qualifications. An interesting approach is the HSE approach to regulating research dives, namely dividing this activity into *Media, Scientific* and *Archeological projects*. The qualifications of candidates participating in a given project should be precisely defined, both when collecting information for the media and proper research dives. The project is subject to occupational risk assessment and all the formalities related to this assessment. Definitely less, comparing to Polish legislation, there is less information about the equipment or requirements regarding the diver's equipment or diving base. Information about the organisation process and safety procedures prevails, this ultimately more closely resembling professional diving than recreational diving.

In other countries, all types of diving for research purposes have their standardisation in organisations dealing with occupational health and safety (including extreme forms such as cave diving). In the United States, recommendations for organising underwater tests have been issued by the AAUS Standards (*American Academy of Underwater Sciences*), where guidelines are published and the projects carried out are subject to review [16]. AAUS introduced functional concepts defining the persons responsible for the project, such as: DSO (*Dive Safety Officer*) and SO (*Safety Officer*). You can also find guidelines for diving in closed circuit apparatus, as well as the implementation of saturation diving projects (i.e. studies under the surface of water calculated not in hours but in days).

Such guidelines are open - they impose basic safety principles and importantly determine the scientific functions of individuals in a given research project. However, the position on the DSO function is given to people with extensive experience in diving. In addition, the division of responsibility for individual activities on DSO and SO was introduced. Such persons are responsible for the quality of the collected information or samples, and matters related to safety, the organisation of diving and emergency situations. In order to be able to perform more advanced work, candidates for individual positions have to take additional courses and get the appropriate number of internship dives (which at the same time allows for a higher level of advancement).

Since the 1990s, the United States has been developing diving standards specialised in carrying out projects at great depths. The pioneer of this dive was Dr. Richard Pyle, who has been diving to depths below 100 m since the early 90's, where he conducted underwater research [1]. Using the technique of diving at great depths, he has discovered over 100 new species of fish so far. In addition, he was also involved in the development of decompression theory [17]. It is worth adding that advanced dives were not aimed at establishing any diving record, but were only scientific in nature. As a result, apart from the new species described, there was also an approximation of the basic ecological processes occurring in nature at great depths [18].

Thus, diving for scientific purposes, a field combining several extremely different activities, is constantly developing, including behavioral studies on the impact of divers on the studied fish [19]. However, it is

important to systematise the methodologies used, as well as to maintain the archiving of the received data, which are often not published, which may be lost.

It should be mentioned that the work on international nature projects also includes volunteer divers. Currently, apart from universities and institutes, research projects related to the development of broadly understood civic science are carried out and divers undertake cooperation with scientists from the relevant field, helping the *non-profit* in research. The level of implemented projects is high, although the divers are not directly connected to science. One of the organisations that has entered the status of scientific research, GUE (Global Underwater Explorers), implements among others, the Baseline project. The goal of this project is to observe the changing underwater environment. At the same time, a dozen other foundations (non-profit organisations) in various countries carry out numerous projects. Unfortunately, most of them are implemented outside our country.

Fig. 1 A new crustacean discovered by diver Matije Petkovica in a flooded cave Krupajsko vrelo in Central Serbia (by Jarosław Kur).

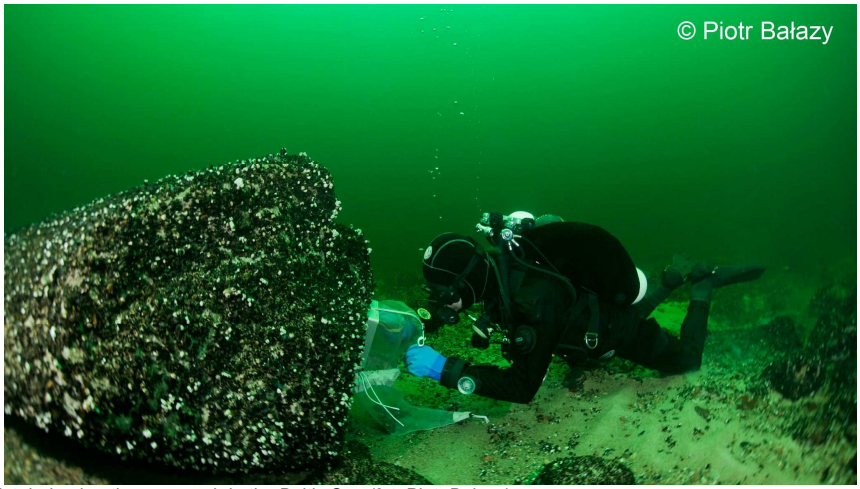

Fig. 2 Underwater naturalist during benthos research in the Baltic Sea (fot. Piotr Bałazy).

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