Chapter

# Diving as a Scientist: Training, Recognition, Occupation - The "Science Diver" Project

*Alexandros Tourtas, Kimon Papadimitriou,*
*Elpida Karadimou and Ralph O. Schill*

## Abstract

Conducting scientific work underwater is a challenging endeavor. From collecting samples to protecting underwater cultural heritage sites scientific divers need to address issues concerning scientific methodology, diving safety, professional acknowledgement, training, legal implications etc. All of these matters are handled in different ways depending on factors like region, organizations involved, legal framework, diving philosophy etc. producing a diverse framework on scientific diving as a distinct type of underwater work. The ScienceDIVER project's main objective is to study and analyze this fragmented landscape, in order to provide insight and suggestions towards a commonly accepted framework that will promote scientific diving as a means of forwarding knowledge both within the scientific community and its interaction with the public.

**Keywords:** scientific diving, dive training, professional diving, diving legislation, diving safety

## 1. Introduction

For more than a century now the underwater world has yielded priceless information on a variety of scientific disciplines. Whether it is the amazing mechanism and the impressive cluster of bronze sculpture from the Antikythera Shipwreck [1] or the valuable measurements on biodiversity and how climate change affects the ecosystem (among others [2]), the data that derive from underwater projects enrich our perception of the world daily and significantly. Going through this long list of underwater endeavors it becomes evident that dive-based research is considered a valuable tool in scientific progress. New data along with new methodologies spring out of the challenging underwater environment enhancing scientific processes and results. Moreover, diving for scientific purposes is also considered nowadays a substantial part of professional development for scientists that want to expand their horizon or excel through the development of specialized skills and expertise. Thus, it has become part of a growing business sector that combines the scientific world with the maritime industry. Established terms such as *Blue Growth* and *Blue Economy*[1] or even recently emerged ones such as *Blue Science*[2] reflect the dynamic

[1] https://ec.europa.eu/maritimeaffairs/policy/blue_growth_en

[2] https://www.euromarinenetwork.eu/activities/blue-science-blue-growth

environment that the combination of several scientific fields can create working with the relevant public or private institutions, in order to promote social and financial development.

However, a career path to scientific diving (SD) is not clearly evident to those who seek to follow it, either students or scientists who want to forward their research underwater. The reason is probably the existence of multifarious ways in which different parts of the world or different established frameworks approach scientific diving as a part of their activity. The relevant landscape is chaotic not in the sense that it is totally absurdum of course, rather than in the mathematical sense of the term meaning that it has many variables that sometimes interact and other times remain idle, creating an unstable model for the harmonization of procedures and accreditation. Differences in philosophy that span from minor dissimilarities in definitions [3–9], to completely unlike and sometimes controversial approaches on features like health and safety [3, 5, 7, 10–13], remuneration and professional acknowledgment. That being said, there are of course established frameworks that do work on a regional, national or even continental level that have been developing for decades (among others [14–16]). Yet, since science leads the way in joining multi-backgrounded people for the promotion of knowledge and has in a way already achieved a global understanding on methodology and procedures, one should expect or even better strive towards the creation of a common framework for the scientific diving community as well, so as to promote research and expand international collaboration. United Nations' declaration of the decade 2021–2030 as the *Decade of Ocean Science for Sustainable Development*[3] is for example a great opportunity for nations to work together in order to generate the global ocean science needed to support the sustainable development of our shared oceans. Scientific diving could be a major device in providing an effective framework for the promotion of *Ocean Literacy*[4] and the enhancement of interaction between science and the public.

All the above generated the idea of a focused research on this particular field that would provide insight on effective ways for the creation of a unified scientific diving framework. The project "ScienceDIVER: Cross-sectoral skills for the blue economy market"[5] started in November of 2019 and comprises the joint effort of three Universities (Aristotle University of Thessaloniki, Greece - University of Calabria, Italy - University of Stuttgart, Germany), a research Institution (DAN Europe) and three companies representing the advisory maritime industry (Atlantis Consulting, Greece – envirocom, Germany – Marine Cluster Bulgaria). It is funded by the European Maritime and Fisheries Fund (Blue Economy 2018[6]) and its main objective is to support the development of blue and smart cross-sectoral skills, in order to meet the evolving needs in the labor market of Blue Economy. By building solid -long lasting- collaborations and structures between academia and industry it aims to offer standardized training and clear career pathways to diving scientists within the European Union. The project is structured in three phases. Firstly, there is the mapping of the relevant landscape and the assessment of needs. Subsequently the consortium will develop tools for the promotion of the project's objectives and lastly there is the testing phase and the provision of viable solutions along with the final results.

[3] https://en.unesco.org/ocean-decade; https://oceandecade.org/

[4] https://oceanliteracy.unesco.org/

[5] https://www.sciencediver.eu/

[6] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/emff-03-2018

## 2. Methodology

This chapter was produced based on data from the first phase of the project. For all the reasons stated above mapping the landscape is a challenging endeavor. In order to approach the subject, the work was divided in five separate tasks. First one was mapping the stakeholders. Since it is nowadays widely accepted, both for professional and social reasons, that knowing the people involved is essential for the success of any management plan, identifying the stakeholders became a priority. The second task was in essence an expansion of the first one, since it comprises focused interaction with selected stakeholders such as competent organizations and policy makers. Both of the above two tasks were used as tools for the production of the following. Third task was to map the training framework concerning scientific diving. Task number four aimed at providing a view on the relevant legal framework, whereas the last one was focused on presenting matters of professional acknowledgement.

Data were gathered from various sources. Bibliography seems to be limited on the specific topic [17–20], since the bulk of scientific diving literature is mostly devoted to the presentation of projects or dedicated to specialized procedures, e.g. diving physiology or hazmat diving, rebreather diving etc. (for a list of indicative publications see [21] but also [22–25]) and not on theoretical matters concerning overall methodology and processes. This chapter is actually a way of contributing to this area of interest by disseminating the results of the project's survey. Most of the material used was taken from official texts provided by organizations that are either focused on or adjacent to scientific diving. Corpora with scientific diving guidelines and standards, various manuals (training, guidelines etc.), educational material etc. [3, 5, 7, 10, 12, 13, 26] that are provided by these organizations entail basic information concerning procedures, prerequisites, certification etc. but also reveal, although not straightforward the philosophy behind the choices on these matters. In other words, analyzing the data one may find clues on the various factors that create the general context that has led to those choices. On a more direct approach, once the stakeholders were identified and assessed, a series of interviews took place with various key players, in order to receive some insight to specific issues. In most cases, in order to keep a coherent approach, predefined questionnaires were used in the communication. Additionally, questionnaires were used also on specific subjects (e.g. citizen science and SCUBA diving) aimed at gathering data from a larger base like for example the recreational diving community. Beyond that, a lot of information was produced by online sources, such as official (and unofficial) websites (among others [2, 14–16, 27, 28]), social media etc. which were critically assessed and provided a more popular aspect to the research than the sterilized image official documents or official representatives do.

Moving from the greater context to more specific ones and trying to keep the overall picture while focusing on more specific areas the study was carried out on several levels. Starting from a global perspective, the first level's aim was to provide an overview of the situation at various parts of the world organizing big clusters. Most of these clusters were representative of continental regions (Europe, America, Australia, Asia, Africa) and the analysis was carried out on a superficial level providing, as stated above, an overview of the situation. More extensive was the study in selected areas. Europe was obviously the main focal point, however more detailed analysis was produced as well for other regions that were considered to have an important background in scientific diving such as North America (USA and Canada), Australia and New Zealand, South Africa, certain Asian countries etc. Deeper examination was then decided to be put forward in five "focus countries" in the EU (Croatia, France, Germany, Greece, Italy) for them to be used as "case studies" keeping in mind that these would also probably serve as testing countries in the implementation phase of the project.

Since this is an ongoing project and data gathering never stops on one hand and the data pool is considerably large on the other, there were certain assumptions made, in order to go on with the process. Such assumptions would be that the data provided by official websites are indeed valid and updated, that the data provided by various contact persons are true and correct and that in all cases there may be more information available that has not been located yet during bibliography or online searches, or has not been mentioned by the interviewees.

## 3. Training framework

The study of the training framework was deemed to be extremely important, since it is the backbone of every diving scheme. It entails all the theoretical and methodological information of each diving framework and has been designed to transmit this information from one person to another, thus it is designed to be comprehensible and coherent. The scope of this task was to provide an overview of the scientific diving training landscape and through comparative and analytical tools to offer some insight on the various approaches that are taken spotting either common ground or indisputable differences. In short to provide a critical map of this entangled network. The objectives set in order to provide this result were firstly to make a list of all the official diving courses related directly or indirectly to scientific diving, to study them and produce some analytical/comparative interpretations and discuss them, in order to come up with relevant conclusions.

A total of 33 diving courses were presented and studied [28–50]. The data gathered comprised basic information about the training agency and the specific course (title, weblink, short description), more detailed data concerning the content and the learning objectives (theoretical knowledge and practical skills), some data about logistics (examination, region, prerequisites, training material, certification requirements and contact person information, i.e. name, position/assignment, contact info). In addition to all the above, a quantitative attribute was placed expressing the relevance of the specific course to scientific diving. The scale span from 3 (max) which indicates a direct reference to SD in course title and description to 1 (min) stating that there is no reference to scientific diving, although some of the courses' content is adjunct to it, insinuating a low relevance. Relevance factor index 2 represents the area between the two extremities with courses that although not named as such, include references to scientific diving in their syllabus. The data derived from all available sources (see above in methodology, p. 3).

Once the list was ready, the analytical phase of the study begun. For methodological reasons the following scheme "Training standards ->Training course -> Certification -> Qualification/recognition" (**Figure 1**) was adopted in order to be able to organize/categorize the data (training courses, organizations, learning objectives, material, prerequisites etc.). More specifically, four [4] criteria categories were recognized, i.e. (a) Prerequisites (input), (b) Technicalities


**Figure 1.**
*Training scheme as approached by the study.*

(durations, costs, number of participants, etc.), (c) Learning objectives (knowledge and skills) and (d) Certifications (outputs). The above criteria were selected in order to allow the description of the training courses on the context of "pathways", originating from an entry point (Prerequisites), passing through a fulfillment phase (Learning Objectives) and resulting to a destination point (Certification) (**Figure 2**). Technicalities were considered as a complementary set of information for the logistics of each training course. It was later decided to let this part aside because the complexity of adjusting factors (region, currencies and local financial context, flexible training timelines etc.) made it impossible to gather usable data for comparative analysis and moved beyond the scope of the intended study.

From analyzing the gathered information that comprises a variety of training courses, the study has concluded to six [6] recognizable qualification systems, which are directly related to scientific diving: (a) American Academy of Underwater Science (AAUS) /Canadian Association of Underwater Science (CAUS), (b) Australian Diver Accreditation Scheme (ADAS), (c) Confédération Mondiale des Activités Subaquatiques (CMAS), (d) European Scientific Diving (ESDP), (e) Global Underwater Explorers (GUE), (f) Health and Safety Executive (HSE). Apart from CMAS and GUE the other four (AAUS, ADAS, ESDP and HSE) are not training agencies, but are providing qualification. These organizations provide standards for the creation of training courses by their members (e.g. for AAUS see [51]). Comparison was held on three levels (see **Table 1**) following the scheme on **Figure 2**.

The first one was about prerequisites. Features that were considered were the entry level – diving certification needed for a diver to begin scientific diving training, administrative matters such as current professional status, age limits, nationality issues etc., medical requirements, swimming proficiency and watermanship standards. It was also noted if and what kind of entry exams are required and whether there is a need to prove experience through the number and the type of previously logged dives. Summarizing the results, it seems that there is a common threshold concerning existing dive certification. All of the systems require a degree of recreational diving status (whether basic e.g. Open Water Diver or novice e.g. CMAS **, Rescue Diver or equivalent) in combination with Basic Life Support capabilities (e.g. CPR, first aid, defibrillation, oxygen provision). Most of them require medical examination and again all of them require a number of logged dives to prove some kind of experience, although the number and type of dives fluctuates from a minimum of 25 dives of any type to more specific demands like dive planning, participation to science projects etc.

The second level of analysis focused on learning objectives. The idea here was that if one breaks down the complex structure of these training systems, the basic elements that they are made of are the "learning objectives". Kind of like the genes in an organism. The selection/combination of learning objectives, either those referring to theoretical knowledge, or those that have to do with practical skills is essential since they are the building materials of the training courses and this process reflects their scope and objectives. Breaking down the courses and analyzing the basic themes on which they are based resulted in a comparative list containing


**Figure 2.**
*Training "pathway".*

| | AAUS | ADAS | CMAS | ESDP* | GUE | HSE |
|---|---|---|---|---|---|---|
| **PREREQUISITES** | | | | | | |
| **ENTRY LEVEL (CERTIFICATION)** | • | • | • | • | • | • |
| Autonomous diver". ISO 24801-2:2007 (e.g. Open Water Diver). | • | • | | | | • |
| CMAS** or equivalent (e.g. Rescue Diver) | | | • | • | • | |
| EFR | | | | | | • |
| **ENTRY EXAMS** | • | • | | | | |
| **ADMINISTRATIVE** | • | | | | • | |
| **MEDICAL** | • | • | | • | • | • |
| **SWIMMING / WATERMANSHIP** | • | • | | | • | • |
| **EXPERIENCE** | • | • | • | • | • | • |
| Logged dives | • | • | • | • | • | • |
| Check dive | • | | | | | |
| **LEARNING OBJECTIVES** | | | | | | |
| **DIVE SAFETY** | • | • | • | • | • | • |
| **PROJECT MANAGEMENT** | • | • | • | • | • | • |
| **SCIENTIFIC METHOD** | • | | • | • | • | • |
| **DATA RECORDING & HANDLING** | • | | • | • | • | • |
| Methods and Techniques | • | | • | | • | • |
| Mapping | • | | • | • | | |
| Data Management | | | • | • | • | |
| UW Imaging | • | | • | • | • | |
| **LEGAL ASPECTS** | • | • | • | • | • | • |
| **DIVE THEORY** | • | • | • | • | • | • |
| **DIVE MODES** | • | • | • | | • | • |
| **SEAMANSHIP** | • | | • | | • | • |
| **SPECIAL CONDITIONS** | • | | | | | • |
| **SPECIALIZED EQUIPMENT** | • | | • | • | • | • |
| Full face mask | • | | | | | |
| Dry Suit | • | | | | | |
| Communications | • | | • | | | • |
| Dive Propulsion Vehicle (DPV) | • | | | | | |
| SMBs/Lift Bags | • | | • | • | | |
| Line Reels | • | | | | | |
| Compressors | | | • | | | • |
| **OTHER TOPICS** | • | | • | • | • | |
| **CERTIFICATION** | | | | | | |
| **TITLE** | • | • | • | • | • | • |

| | AAUS | ADAS | CMAS | ESDP* | GUE | HSE |
|---|---|---|---|---|---|---|
| Scientific Diver | • | | • | • | • | |
| Professional Diver | | | | | | • |
| Occupational Diver | | • | | | | |
| **RECIPROCITY** | • | • | | | | • |
| **DISCIPLINES** | • | • | • | • | • | • |
| Oceanography | • | • | • | • | • | • |
| Archaeology | • | • | • | • | • | • |
| Biology | • | • | • | • | • | • |
| Ecology | • | • | • | • | • | • |
| Geology | • | • | • | • | • | • |
| Engineering | • | • | • | • | • | • |
| Media | | | | | | • |

*(KRISTINEBERG MARINE STATION).

**Table 1.**
*Comparative analysis of scientific training schemes.*

the following recognizable features: (a) dive safety, (b) project management, (c) scientific method, (d) data recording & handling (methodology, mapping, data management, u/w imaging), (e) legal aspects, (f) dive theory, (g) dive modes (e.g. SCUBA, CCR, SSD), (h) seamanship, (i) special conditions (e.g. chamber, night, deco dives), (j) specialized equipment (e.g. full face mask, dry suit, communications, DPV, lift bags, line reels, compressors), (k) other topics (e.g. u/w navigation, search methods, video systems). Through that process it became obvious that there are certain topics that are common to all training schemes such as dive safety, project management, legal aspects and dive theory. Moreover, it is evident that most of the systems (five out of six) provide also training on scientific methods, data recording and handling, dive modes and specialized equipment. Although there are differences on the extend and the ways each topic is approached, the aforementioned learning objectives seem to define the content of the term scientific diving as far as training is concerned.

The final level of analysis referred to the output of the whole process and more specifically to the provided certification and its acknowledgement. An important feature was the title granted after the completion of the training, due to the fact that it is absolutely related to its training systems' approach. Thus, along with the obvious Scientific Diver title, one comes across the terms: professional diver (HSE) and occupational diver (ADAS). This comes as no surprise of course, since the debate whether scientific diving belongs or not to the greater professional/occupational diving scheme is an old one and still raging. Moreover, the fragmentation of the scientific diving landscape also results in certifications not being globally recognized, although reciprocity arrangements are becoming more and more common between organizations, at least in terms of training. Lastly, it seems that the most common scientific areas where a scientific diving certification comes to fruition are oceanography, archaeology, biology – ecology, geology, engineering and as an adjacent field, media production for scientific purposes.

On a larger scale and beyond the three levels of analysis presented here, there are some other notable issues that were raised during the study. The fact for example that GUE and CMAS, the two systems that are also training organizations are preferable for individual training, since the rest require either a connection with a scientific institution or a professional status. These limitations also result in a tendency for gaps in the existing qualification systems to be covered by courses provided by training organizations (e.g. recreational diving agencies and universities). In other words, when none of the presented schemes is an option, which is quite common in many countries that have either a poor or no scientific diving framework at all, recreational diving courses with learning objectives related to scientific diving or short seminars organized by universities or relevant to the subject organizations seem to compensate for the lack of officially recognized certification. Lastly, a topic of an ongoing discussion that seems to be very interesting refers to the role of volunteers, amateurs and citizen scientists in research projects. There are courses for example, like the ones organized by the Nautical Archeological Society (NAS) in the UK [46] that have been educating citizens in underwater archaeology for decades now. Citizen science is rapidly developing in other scientific areas as well, most prominently in ecology and underwater biology, requesting from recreational divers to submit data to scientific projects [52–54]. It is evident that the results of this discussion affect the form of SD training schemes and the option of introducing the act of raising awareness, educating people and finally certifying them officially to participate in scientific diving projects could be a big part of scientific diving training in the future.

## 4. Legal framework

The importance of the legal framework surrounding scientific diving activities is in a way self-evident. It provides the solid base on which theory becomes practice and becomes -in the framework of this study- the liaison between training (i.e. structuring the method) with professional acknowledgement (i.e. applying it on the field). The diverse landscape that has been repeatedly mentioned so far is obviously reflected on legal matters as well. Although certain steps have taken place the last couple of decades, the present legal framework is still either pretty complex or insufficient (if nonexistent) making scientific diving a difficult task in terms of standardization, insurance, mobility (reciprocity) of scientific divers etc. Thus, it was decided that an overview of the legal framework along with an analysis of selected features or specific regional characteristics was absolutely necessary in order to comprehend the present situation, provide insights and produce suggestions for optimization.

The legal study was carried out following the basic methodology of the project, collecting data from all (mainly official in this case) available sources and communicating with stakeholders (e.g. diving industry, policy makers, scientific diving institutions) focusing on the legal aspect of their organization and activity. The data were organized and analyzed in such a way, so as to elucidate, if possible, the gray areas and identify the gaps among the various legal structures that have been built around scientific diving, in order of course to pave the way towards unification or at least cooperation.

The study comprises three basic parts. The first one focuses on definitions. Recognizing the importance of understanding the meaning of words and how much they represent the general principles of the organization issuing them on one hand and affect the implementation of each scheme on the other, it was deemed critical to have a more detailed look into them [3–9]. A list of definitions was created for comparative reasons containing the various interpretations that organizations involved in scientific diving apply to fundamental terminology. Besides the intuitively related terms, such as *scientific diving, scientific diver, science diver, scientific* *diving instructor*, the list covers other major areas of diving activity such as commercial, occupational and recreational diving with the relevant terms, diving modes (e.g. technical diving, surface supply, mixed gas diving, CCR) as well as other forms of diving activity that have some kind of relevance with the investigated subject (e.g. police and military diving, rescue procedures). Looking at the results one can see that although the differences are minor the divergence further down the road is in certain cases substantial creating a hiatus. However, the basic definitions are more or less the same concluding that whatever the professional status or the dive mode scientific diving is defined by (a) its scientific purpose and (b) its scientific method.

The second part of the legal study examines the international framework covering scientific diving. Analyzing the current situation in various countries the overall picture is again fragmentary. Differences occur on several levels, such as for example the maturity of the legal framework itself. Certain countries (e.g. Australia and New Zealand, Canada, South Africa, UK, and USA) have a long tradition in occupational diving which means that they have an established legal framework. On the contrary there are several countries, where scientific diving is not mentioned at all in legal texts, even though there is a scientific community that tries to regulate itself through recognized recreational diving schemes. In summary, one could suggest that when not directly addressed the topic of scientific diving is most often covered by labor laws or laws regulating maritime affairs. Another level of differentiation includes means of authority and enforceability. In countries that do have an established framework, authorities follow a scheme with four cooperating parts (**Figure 3**): (a) Statutes laws that are at the top of the legal hierarchy and are created by a legal body. (b) Regulations. A regulation is the second step in the hierarchy of law. Regulations have the force of law which is made by an executive authority under powers delegated by primary legislation. (c) Codes of Practices. Codes of Practices do not have the force of the law. They provide guidance from the regulator on how to comply with requirements and obligations under work health and safety laws and regulations. They can influence court proceedings under the health and safety laws and regulations. (d) Standards. They do not have legal force, but can similarly be used to establish norms for certain classes of diving. These are voluntary consensus documents, which, although not automatically a legal document, may be incorporated into legislation by reference or used in private contracts as a set of specifications and procedures. Thus, besides national legislations the study included official texts issued by scientific diving organizations, such as the AAUS, ESDP, EUF (European Underwater Federation) etc. [3–5, 10–13, 26, 55–58]. This leveled structure means that both the formation and the enforcement of the relevant legislation is distributed to several stakeholders rather than being a solemn responsibility of the state. Following a bottom up approach, organizations need to look after the validity of their procedures according to standards and code of practices they helped to create, collective organisms and government departments have to check and modify regulations whereas national administration is responsible for the creation, modification and enforcement of the statutory laws. Of course, that's a scheme that works in countries that do have a mature legal framework.

The third part of the legal study was based on more thorough research covering the focus countries (i.e. Croatia, France, Germany, Greece and Italy). Specified


**Figure 3.**
*The four levels of legal engagement.*

research topics were investigated in order to provide further insight into the matter. Since it would be lengthy endeavor to present the content of the research here, it would suffice to say that the results were more or less anticipated and the picture drawn was not at all different from the one described in the previous paragraph. What is interesting enough is than in none of the focus countries the legal framework is specifically directed at scientific diving. Running the gamut there are (a) professional diving environments like the one in France regulating matters of scientific diving and addressing the matter on an occupational basis according to labor legislation, (b) lighter or less structured frameworks that are more related to scientific diving yet less official (e.g. Germany, Croatia, Italy) and (c) completely absent frameworks, like the case of Greece that has minimal scientific diving reference in official texts.

Concluding and keeping in mind that the scope of the project focuses on the European level, one could definitely suggest that there is a clear need for clarifications and legal framework improvements concerning scientific diving for the vast majority of countries and an effort to agree on basic principles in order to unify the regionally based arrangements that have been running so far. Especially within the European Union the tools for harmonization on such matters already exist and through this framework the scientific diving community can strive for a widely accepted legal structure.

## 5. Professional acknowledgement

Same as training and legal aspects, professional acknowledgement of scientific diving is a complex matter. An introductory statement could be that on a global scale scientific diving is rarely recognized as a distinct professional activity. However, since this statement is quite vague, the professional acknowledgment study aimed at providing a more accurate assessment of the situation. Presenting the international *status quo* and then focusing on particular regions and situations produced an evaluation of the degree of professional acknowledgment based on relevant data and expert opinions. In order to organize and analyze the data a list of selected criteria was created based on (a) definitions (e.g. scientific diving purpose, scientific methodology), (b) legal framework (e.g. official recognition by the state, relevant legal framework), (c) remuneration (occupational aspect) and (d) reciprocity (regional and institutional).

In general, one can suggest that the status of the relevant legal framework is directly affecting professional acknowledgement. Thus, in regions with an established legal framework professional recognition is much more developed that in the case of regions with a lack of or an insufficient legal framework. In the latter, recognition of scientific diving credentials becomes unofficial and is regulated on an organizational level e.g. by institutions or the private sector according to circumstantial needs.

An interesting outcome that derived from the study was the notion that scientific diving in practice comprises two interacting parts. The first one is obviously the scientific method used to acquire the information from the underwater environment. Disciplines like archaeology, biology, engineering, geology, medicine, oceanography, meteorology have for a long time now already developed methodological tools designed for underwater work. The second one refers to the diving aspect and is a cluster of techniques (or dive modes) that have to do with all the subsidiary activity that needs to take place during an underwater scientific project. Deep diving, heavy lifting, setting up the survey area, scientific equipment maintenance, recovering of artifacts and samples and other tasks that require a variety of skills which range from basic recreational diving skills to more demanding diving procedures, such as surface supply, mixed gases, lift bags handling, power tools etc. The first part is easily defined and accepted, as stated previously in this text. The second part though is actually an area of debate, since it involves tasks that are traditionally connected to commercial diving [3].

Another point of interest is the distinction between scientists that organize their own scientific diving projects as part of their wider research and those that are directly employed by institutions to work specifically for underwater scientific work. In other words, scientists that also dive and scientific divers explicitly hired for this purpose. This distinction refers to the occupational nature of the underwater work performed and becomes part of the relevant discussion. Once again there are cases where the distinction becomes difficult and definitions about occupational diving like the one used by ADAS [4] try to provide clear solutions stating that "*Diving in the course of employment (irrespective of whether or not diving is the principal function of employment or merely an adjunct to it) and comprising all diving work carried out as part of a business; as a service; for research; or for profit.*" is occupational. Of course, not everybody agrees with this statement and the debate lingers.

Another aspect of the occupational nature of scientific diving is remuneration. Information about scientific divers' remuneration is difficult to acquire due to the multifactorial nature of wages (depending on region, legal framework, professional status etc.) and the sensitivity of personal data involved. A general conclusion to be made though is that payment can be produced either in a direct way, in the form of a salary for scientific diving services or indirectly as compensation, allowance, supplementary payment etc. which aligns with the aforementioned distinction between scientists that dive in the scope of their work or scientific diver explicitly hired for that purpose.

Lastly, insurance - wise when things are not specifically regulated by the occupational diving framework and insurance is not provided by the state (public insurance), most of the countries recognize either DAN insurance [59] or other relevant occupational insurance schemes form the private sector. Accident insurances are offered by various insurance providers. However, they only cover the costs of treatment, which can of course be very cost-intensive. Much more important are the benefits that may be provided by the social insurance schemes, e.g. in the case of occupational disability due to an accident.

## 6. Conclusions

Summarizing results and discussion, here are some final thoughts on the subject. From a starting point that unification is a good thing and will promote the interests of the scientific diving community, the fragmentation that the study of today's landscape reveals needs to be addressed on certain fundamental issues.

A major decision that needs to be made towards unification is related to the basic questions on the professional nature of scientific diving. Is scientific diving an occupational activity? Should scientific diving follow commercial diving practices? Should it abide by strong rules that provide a stable framework or should it serve a less rigid yet versatile framework that provides options for more contexts?

It is impossible if not irresponsible to provide answers hastily. The scientific diving landscape is at the moment fragmentary due to regional or professional micro-management or simply because it is still undeveloped or immature in many countries, even in some that do have noticeable scientific diving activity. Thus, the development of a widely accepted scientific diving framework (training, legal, professional) is not just a way to enhance reciprocity among the existing ones, but more importantly a way to promote scientific diving in general.

There is an ongoing effort for the creation of a World Scientific Diving Training Council, while in our area of interest, Europe, the ESDP tries to bring people from various countries and backgrounds together during conferences and workshops [60–62]. The ScienceDIVER project itself is proof that work is being done towards that goal. Hopefully these efforts will come to fruition soon and scientific diving will be sufficiently supported in the years to come.

This chapter follows the project's primary goal which is to promote a new holistic approach to the theory behind the formation of a scientific diving framework. As stated above, bibliography focused on the theoretical matters of scientific diving is limited. In most cases there are thoughts and insights among the lines of texts dedicated either to the presentation of underwater scientific work or to presentations of the current situation in specific regions. In this chapter we present the data gathered during the analytical phase of the project providing a wide view on the relevant landscape concerning what we believe to be the main pillars of this structure, i.e. training, legal framework and professional acknowledgement. Most importantly through the analysis of the various tasks performed, we provide our suggestion for a methodology addressing this multileveled and complex cluster of issues that we believe corresponds to the fundamental features of scientific diving. The various approaches expressed hitherto concerning these three major features have been discussed in the relevant sections in a way, so as to pinpoint the key issues of confrontation, such as the content of training courses (e.g. learning objectives and prerequisites), the various legal implications, safety and insurance policies, salary issues etc. Having all the above gathered in one study will serve as a base for the development of new scientific bibliography focused on the issues raised in this text. In other words, we hope that this text will serve as a trigger point for the production of new scientific literature of the same holistic nature, since the problems we face will only be efficiently handled through collaboration and convergence. In order to do so though we need more people and projects working on the issue. Whether the authors of these future study agree or not with the thoughts expressed in this text is of minor importance, since the discussion will have commenced.

## Acknowledgements

The ScienceDIVER project is funded the European Maritime and Fisheries Fund (Blue Economy 2018). The data used in this chapter derive from deliverables produced by the project's partners. Contributions were made by Konstantinos Tokmakidis and Georgia Kalantzi from AUTh, Franz Brummer from UST, Fabio Bruno and Matteo Collina from UNICAL, Angelos Manglis, Themistoklis Ioannidis, Paschalina Giatsiatiou and Dimitra Papadopoulou from ATL, Salih Murat Egi and Guy Thomas from DAN, Anton Krastev, Rumen Stoyanov, Ilze Athanasova and Siyana Angelova from MCB.

## Conflict of interest

The authors declare no conflict of interest.

*DOI: http://dx.doi.org/10.5772/intechopen.94601*

## Author details

Alexandros Tourtas[1]*, Kimon Papadimitriou[1], Elpida Karadimou[1] and Ralph O. Schill[2]

1 Aristotle University of Thessaloniki, Thessaloniki, Greece

2 ENVIROCOM, (www.envirocom.de), Tübingen, Germany

*Address all correspondence to: alextourtas@topo.auth.gr

## References


[1] Kaltsas, N., Vlachogianni, E. & Bouyia, P. (eds.) 2012. The Antikythera Shipwreck. The ship, the treasures, the Mechanism. Athens: National Archaeological Museum, 303 pp. ISBN-13: 978-9603860310

[2] Molinos, J.G., Halpern, B.S., Schoeman, D.S., Brown, C.J., Kiessling, W., Moore, P.J., Pandolfi, J.M., Poloczanska, E.S., Richardson, A.J. and Burrows, M.T., 2016. Climate velocity and the future global redistribution of marine biodiversity. Nature Climate Change, 6(1), pp.83-88.

[3] AAUS Standards for scientific diving manual [Internet]. 2019. Available from: https://aaus.org/diving_standards [Accessed: 2020-07-30]

[4] ADAS. Scientific diving [internet]. 2020. Available from: https://adas.org.au/careers/scientific-diving/ [Accessed: 2020-10-10]

[5] CMAS Standard for scientific diver. CMAS Scientific Diver. CMAS Advanced Scientific Diver. CMAS Scientific Diving Instructor. CMAS Scientific Diving Confirmed Instructor [Internet]. 2020. Available from: https://www.cmas.org/science/standards [Accessed: 2020-10-15]

[6] Italian Association of Scientific Divers [Internet]. 2020. Available from: http://www.aioss.info/default_e.asp [Accessed: 2020-10-15]

[7] NOAA Diving Manual 5th Edition [Internet]. 2017. Available from: http://tecvault.t101.ro/NOAA%20Diving%20Manual.pdf [Accessed: 2020-07-30]

[8] Flemming NC, Max MD, editors. Scientific diving: a general code of practice. 2nd ed. UNESCO Pub.; 1997. 254 p. ISBN-13: 978-9231032509

[9] US DoL. Occupational Safety and Health Administration. Definitions. Available from: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9978&p_table=STANDARDS [Accessed: 2020-10-15]

[10] HSE Diving at Work Regulations 1997 dated 13 February 2020 [Internet]. 2020. Available from: https://www.hse.gov.uk/diving/qualifications/approved-list.pdf [Accessed: 2020-07-30]

[11] NOAA Diving Standards and Safety Manual [Internet]. 2017. Available from: https://www.omao.noaa.gov/sites/default/files/documents/NDSSM%20Rev%2012%20Feb%202020.pdf [Accessed: 2020-07-30]

[12] Société de Physiologie et de Médecine Subaquatiques et Hyperbares de Langue Française. Société Française de Médecine du Travail. Prise en Charge en Santé au Travail Des Travailleurs Intervenant en Conditions Hyperbares. Deuxième edition. [Internet]. 2018. Available from: https://www.medsubhyp.fr/images/consensus_bonnes_pratiques_reglementation/Sant-au-travail-des-travailleurs-hyperbares-2018-v2.pdf [Accessed: 2020-07-30]

[13] Buone prassi per lo svolgimento in sicurezza delle attività subacquee di ISPRA e delle Agenzie Ambientali. [Internet]. 2013. Available from: https://www.isprambiente.gov.it/files/pubblicazioni/manuali-lineeguida/MLG_94_13_Buone_prassi_attivit_subacquee.pdf [Accessed: 2020-07-30]

[14] AAUS. Overview. [Internet]. 2020. Available from: https://www.aaus.org/ [Accessed: 2020-10-15]

[15] ADAS. Overview. [Internet]. 2020. Available from: https://adas.org.au/adas-overview/ [Accessed: 2020-10-15]

[16] HSE. Overview. [Internet]. 2020. Available from: https://www.hse.gov.uk/diving/ [Accessed: 2020-10-15]

[17] Ponti, M. 2012. Scientific diving: towards European harmonization, *International Journal of the Society for Underwater Technology* 30(4), pp. 181-182

[18] Sayer, M.D.J., Fischer, P. & Feral J.P. 2008. Scientific Diving in Europe: Integration, Representation and Promotion In: *Brueggeman P, Pollock NW, eds. Diving for Science 2008. Proceedings of the American Academy of Underwater Sciences 27th Symposium. Dauphin Island*, AL: AAUS, pp. 139-146

[19] Sayer, M.D.J. 2007. Scientific diving: a bibliographic analysis of underwater research supported by SCUBA diving, 1995-2006 *International Journal of the Society for Underwater Technology* 27(3), pp. 75-94

[20] Sayer, M.D.J. & Barrington, J. 2005. Trends in scientific diving: an analysis of scientific diving operation records, 1970-2004 *International Journal of the Society for Underwater Technology* 26(2), pp. 51-55

[21] Diving Publications. Scientific Diving. US EPA. Available from: https://www.epa.gov/diving/diving-publications [Accessed: 2020-10-15]

[22] Pollock, N.W., Sellers, S.H. & Godfrey, J.M. (eds.) 2016. *Rebreathers and Scientific Diving. Proceedings of NPS/NOAA/DAN/AAUS June 16-19, 2015 Workshop*. Wrigley Marine Science Center, Catalina Island, CA; 272 pp. ISBN: 978-0-9800423-9-9

[23] Kur, J. & Mioduchowska, M. 2018. Scientific Diving in natural sciences, *Journal of Polish Hyperbaric Medicine and Technology Society* 4(65), pp. 55-62 DOI: 10.2478/phr-2018-0024

[24] Balazy, P., Kuklinski, P. & Wlodarska-Kowalczuk, M. 2014. Scientific Diving in polar regions – the example of ecological studies at the Institute of Oceanology, Polish Academy of Sciences, *Journal of Polish Hyperbaric Medicine and Technology Society* 1(46), pp. 65-84

[25] Merkel, B.J. & Schipek, M (eds.) 2009. Research in Shallow Marine and Fresh Water Systems 1st International Workshop - Proceedings Freiberg Online Geology 22

[26] ESDP Common Practices for Recognition of European Competency Levels for Scientific Diving at Work European. Scientific Diver (ESD). Advanced European Scientific Diver (AESD). Consultation Document 1 (rev. 1) [Internet]. 2017. Available from: http://ssd.imbe.fr/IMG/pdf/esdp_consult_1_rev1_april_2017_sd_competency_levels_.pdf [Accessed: 2020-09-25]

[27] CMAS. Overview. [Internet]. 2020. Available from: https://www.cmas.org/ [Accessed: 2020-10-17]

[28] GUE Scientific Diver [Internet]. 2020. Available from: https://www.gue.com/diver-training/explore-gue-courses/foundational/scientific [Accessed: 2020-07-30]

[29] ADAS Certification Conditions [Internet]. 2020. Available from: https://adas.org.au/adas-certification-conditions/ [Accessed: 2020-07-30]

[30] ADAS Certification Overview [Internet]. 2020. Available from: https://adas.org.au/need-occupational-diving-certificate/ [Accessed: 2020-07-30]

[31] ADAS Training [Internet]. 2020. Available from: https://adas.org.au/training / [Accessed: 2020-07-30]

[32] ADAS Training Courses [Internet]. 2020. Available from: https://adas.org.au/training-courses/ [Accessed: 2020-07-30]

[33] ADAS Training Schools [Internet]. 2020. Available from: https://adas.org.au/training-schools [Accessed: 2020-07-30]

[34] CMAS Scientific & Sustainability Committee. Non-professional CMAS. Scientific Specialty Courses (SSC). ADMINISTRATIVE TEXT [Internet]. 2018. Available from: https://www.cmas.org/science/standards [Accessed: 2020-10-15]

[35] CMAS Scientific & Sustainability Committee. Underwater Geology Course (UGC) [Internet]. 2018. Available from: https://www.cmas.org/science/standards [Accessed: 2020-10-15]

[36] CMAS Scientific & Sustainability Committee. Underwater Cultural Heritage Discovery Course (UCHDC) [Internet]. 2018. Available from: https://www.cmas.org/science/standards [Accessed: 2020-10-15]

[37] CMAS Scientific & Sustainability Committee. Underwater Archaeology Course (UAC) [Internet]. 2018. Available from: https://www.cmas.org/science/standards [Accessed: 2020-10-15]

[38] CMAS Scientific & Sustainability Committee. Ocean Discovery Course (ODC) [Internet]. 2018. Available from: https://www.cmas.org/science/standards [Accessed: 2020-10-15]

[39] CMAS Scientific & Sustainability Committee. Marine Biology Course (MBC) [Internet]. 2018. Available from: https://www.cmas.org/science/standards [Accessed: 2020-10-15]

[40] CMAS Scientific & Sustainability Committee. Freshwater Biology Course (FBC) [Internet]. 2018. Available from: https://www.cmas.org/science/standards [Accessed: 2020-10-15]

[41] CMAS Scientific & Sustainability Committee. Conservation Biology Course (CBC) [Internet]. 2018. Available from: https://www.cmas.org/science/standards [Accessed: 2020-10-15]

[42] CMAS Scientific & Sustainability Committee. Advanced Underwater Geology Course (AUGC) [Internet]. 2018. Available from: https://www.cmas.org/science/standards [Accessed: 2020-10-15]

[43] CMAS Scientific & Sustainability Committee. Advanced Underwater Archaeology Course (AUAC) [Internet]. 2018. Available from: https://www.cmas.org/science/standards [Accessed: 2020-10-15]

[44] CMAS Scientific & Sustainability Committee. Advanced Marine Biology Course (AMBC) [Internet]. 2018. Available from: https://www.cmas.org/science/standards [Accessed: 2020-10-15]

[45] CMAS Scientific & Sustainability Committee. Advanced Freshwater Biology Course (AFBC) [Internet]. 2018. Available from: https://www.cmas.org/science/standards [Accessed: 2020-10-15]

[46] NAS Education. International System [Internet]. 2020. Available from: https://www.nauticalarchaeologysociety.org/Pages/Category/international-system [Accessed: 2020-07-30]

[47] NOAA Science Diver Qualification Requirements [Internet]. 2015. Available from: https://www.omao.noaa.gov/sites/default/files/documents/0306%20-%20NOAA%20Science%20Diver%20Qualification%20Requirements.pdf [Accessed: 2020-07-30]

[48] NOAA Scientific Diver Training and Certification Requirements [Internet]. 2015. Available from: https://www.omao.noaa.gov/sites/default/files/documents/0313%20-%20NOAA%20

Scientific%20Diver%20Training%20and%20Certification%20Requirements.pdf [Accessed: 2020-07-30]

[49] University of Gothenburg. 5th International German - Swedish - Finish European Scientific Diving (ESD) Training Course 2019 [Internet]. 2019. Available from: https://www.euromarinenetwork.eu/system/files/2019/5th%20ESD%20Training%20Course%202019.pdf [Accessed: 2020-07-30]

[50] Coordination of Scientific Divers of Croatia. Scientific Diving Course. Spring 2015. International Centre for Underwater Archaeology Zadar SUB [Internet]. 2015. Available from: http://icua.hr/images/stories/natjecaji/Scientific%20Diving%20Course%20ICUA%202015.pdf [Accessed: 2020-07-30]

[51] AAUS Members [Internet]. 2020. Available from: https://www.aaus.org/AAUS/Members/Current_Organizational_Members/AAUS/Organizational_Members_Public.aspx?hkey=8cfd3868-610c-4285-afc3-57f0d5fa2c09 [Accessed: 2020-07-30]

[52] Cohn, J. P. 2008. Citizen Science: Can Volunteers Do Real Research? *BioScience* 58(3) pp. 192-197

[53] Dickinson, J., Shirk, J., Bonter, D., Bonney, R., Crain, R.L, Martin, J., Phillips, T & Purcell, K. 2012. The current state of citizen science as a tool for ecological research and public engagement. *Frontiers in Ecology and the Environment* 10(6), pp. 291-297

[54] Barnes, J.A. 2017. Public archaeology is citizen science in Arkansas, *Journal of Community Archaeology & Heritage*, DOI: 10.1080/20518196.2017.1308296

[55] HSE Diving at Work Regulations 1997. HSE criteria for approval of non-UK diving qualifications dated 9th July 2018 [Internet]. 2018. Available from: https://www.hse.gov.uk/diving/qualifications/non-uk-diving-qualifications.pdf [Accessed: 2020-07-30]

[56] NOAA Scientific Training and Proficiency Dives [Internet]. 2015. Available from: https://www.omao.noaa.gov/sites/default/files/documents/0302%20-%20Scientific%20Training%20and%20Proficiency%20Dives.pdf [Accessed: 2020-07-30]

[57] NOAA Science Divers Performance of Working Tasks [Internet]. 2015. Available from: https://www.omao.noaa.gov/sites/default/files/documents/0303%20-%20Science%20Divers%20Performance%20of%20Working%20Tasks.pdf [Accessed: 2020-07-30]

[58] Model Code of Practice for Safe Diving Operations. Prepared by the UNESCO UNITWIN Network for Underwater Archaeology [Internet]. 2013. Available from: http://www.underwaterarchaeology.net/News/UNITWIN_Model_Dive_Code_20190620_EN.PDF [Accessed: 2020-10-10]

[59] Divers Alert Network Europe. Insurance. [Internet]. 2020. Available from: https://daneurope.org/web/guest/insurance [Accessed: 2020-10-16]

[60] ESDP Report 18th Plenary Meeting European Scientific Diving Panel. 11 April 2017 | Station Marine d'Endoume | Marseille [Internet]. 2020. Available from: http://ssd.imbe.fr/IMG/pdf/18th_esdp_meeting_report_vf.pdf [Accessed: 2020-07-30]

[61] ESDP Report. European Scientific Diving Panel (ESDP) 19th Meeting – 26 October 2017 MUMM Brussels & Skype [Internet]. 2017. Available from: http://ssd.imbe.fr/IMG/pdf/esdp_-_minutes_meeting_19_-_261017.pdf [Accessed: 2020-07-30]

[62] ESDP 20th Meeting – 04th May 2018 -University of Stockholm & Skype [Internet]. 2018. Available from: http://ssd.imbe.fr/IMG/pdf/esdp_-_minutes_meeting_20_-20180504.pdf [Accessed: 2020-07-30]