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# Standards of initial training in Occupational Scientific Diving (OSD), a necessity for the mobility of scientists in Europe

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**Abstract**: Diving is an effective way to observe, collect or experiment *in situ* on echinoderms and other coastal bottom living organisms. Using it in an occupational setting is not just a matter of skill. Having it recognized as a scientific technique is a challenge due to the "recreational" image associated with its practice. Its supposed danger and the chain of responsibility that an accident could trigger also make its administrative acceptance difficult. These aspects can constitute obstacles, especially for international collaborations. EU standards validated by Member States can guarantee the mobility of "diving" scientists in Europe. From the 1980s, we understood that the implementation of initial training developed according to these standards and a controlled issuance of certificates guaranteed the safety of the activity and makes underwater interventions possible for the different scientific disciplines concerned. These standards have been defined in the context of the occupational practice of professional scientists. However, the use of the term "scientific diving" in recreational diving, which is not subject to the same training and practice constraints, concerns citizens who may act voluntarily toward sciences. This new semantic blurs the original concept of scientific diving. A clarification between occupational and citizen practice is currently necessary.

**Résumé** : *Normes sur la formation initiale en plongée scientifique professionnelle (OSD - Occupational Scientific Diving), une nécessité pour la mobilité des scientifiques en Europe.* La plongée est un moyen efficace pour observer, collecter ou expérimenter *in situ* sur les échinodermes et autres benthontes côtiers. L'utiliser dans le cadre professionnel n'est pas qu'une question de capacité. La faire reconnaître comme technique scientifique est un défi en raison de l'image "récréative" associée à sa pratique. Son danger supposé et la chaîne de responsabilités qu'un accident pourrait déclencher rendent aussi son acceptation administrative difficile. Ces aspects peuvent constituer des obstacles, surtout lorsque les collaborations impliquent plusieurs pays. Des standards validés par les états membres peuvent garantir la mobilité des scientifiques professionnels "plongeurs"

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en Europe. Dès les années 1980, on a compris que la mise en œuvre d'une formation initiale élaborée selon ces standards et une délivrance contrôlée des certificats garantissaient la sécurité nécessaire rendant possibles les interventions sous-marines pour les différentes disciplines scientifiques concernées. Ces normes européennes ont été définies dans le contexte de la pratique professionnelle des scientifiques. Cependant, l'utilisation du terme « plongée scientifique » dans le monde de la plongée loisir, qui n'est pas assujettie aux mêmes contraintes de formation et de pratique et s'adresse aux bénévoles, brouille le concept originel de plongée scientifique. Une clarification sémantique entre pratique professionnelle et participative s'avère désormais nécessaire.

*Keywords*: Initial training standards ● European Scientific Diving Panel (ESDP) ● Underwater ecology ● Coastal echinoderms ● Citizen scientific diving (CSD) ● Blue Economy

**Abbreviations:**
AESD: Advanced European Scientific Diver
CCR: Closed circuit rebreather
CMAS: World Underwater Federation
CSD: Citizen Scientific Diving
ESD: European Scientific Diver
ESDP: European Scientific Diving Panel
GUE: Global Underwater Explorers
ISO: International Organization for Standardization
OSD: Occupational Scientific Diving
PADI: Professional Association of Diving Instructors
SCUBA:Self-contained Underwater Breathing Apparatus

## Introduction

Soon after the end of the Second World War, scientists (ecologists and archaeologists alike) recognized the scientific potential of diving (Drach, 1948). "The possibility of exploration by diving, and consequently of adding direct vision to direct collecting, ought to make of the eulittoral zone, in the near future, one of the best known parts of the underwater continental shelf" (Drach, 1958).

As echinoderms are a major component of the coastal benthos, this issue is of particular concern when you study them. In this depth range (currently down to the mesophotic zone, thanks to closed circuit rebreathers (Norro, 2016)), diving is the most effective way of penetrating the aquatic environment for several purposes such as inventories, surveys, observation (Guille et al., 1986 ; Galloway et al., 2023) or *in situ* experimentation (Fig. 1). It is also an irreplaceable means of monitoring, for example in the case of outbreaks of *Acanthaster* sp. (Dumas et al., 2020; Chandler et al., 2023) or *Strongylocentrotus* sp. (Filbee-Dexter & Scheibling, 2014; Smith & Tinker, 2022).

## Is diving easy to use for science in Europe?

Diving seems to be a very evident way of investigating coastal environments. However, situations vary greatly from country to country. Depending on the laws in force, diving access to territorial waters can be very difficult, if not impossible, for foreign visitor scientists (Féral & Norro, 2023).

The simplest way would be to manage Occupational Scientific Diving as a whole at the European level. However, due to the principle of subsidiarity of the law, there is no common European education policy. As defined in Article 5(3) of the Treaty on European Union (EUR, 2016), EU cannot take action (except in the areas that fall within its exclusive jurisdiction), unless it is more effective than action taken at the national, regional or local level. Today, each Member State can only issue its own national certifications, if its laws so require or permit. There are no European certificates for Occupational Scientific Diving, hence the need for standards that are as homogenous as possible and effective facing those regulating commercial diving. It is also on this that the effective recognition by the law of Occupational Scientific Diving depends, allowing for specific training, different from that provided for commercial companies or the Navy.

Despite the obvious benefits of its use, diving may mostly evoke leisure and risk (Sayer & Barrington, 2005; Sayer & Forbes, 2007). Despite data analyses proving that diving is not carrying a higher than normal risk (Benjamin & MacKintosh, 2016; Dunford et al., 2020; Flemming, 2021), this image still provokes the reflex of some administrations which prohibits it or links scientific diving to commercial diving whose training and rules in force are not adapted. Various aspects of labor law in several European countries (particularly those concerning the safety and well-being of workers or the liability of the employer) make it impossible simply to recognize certificates obtained

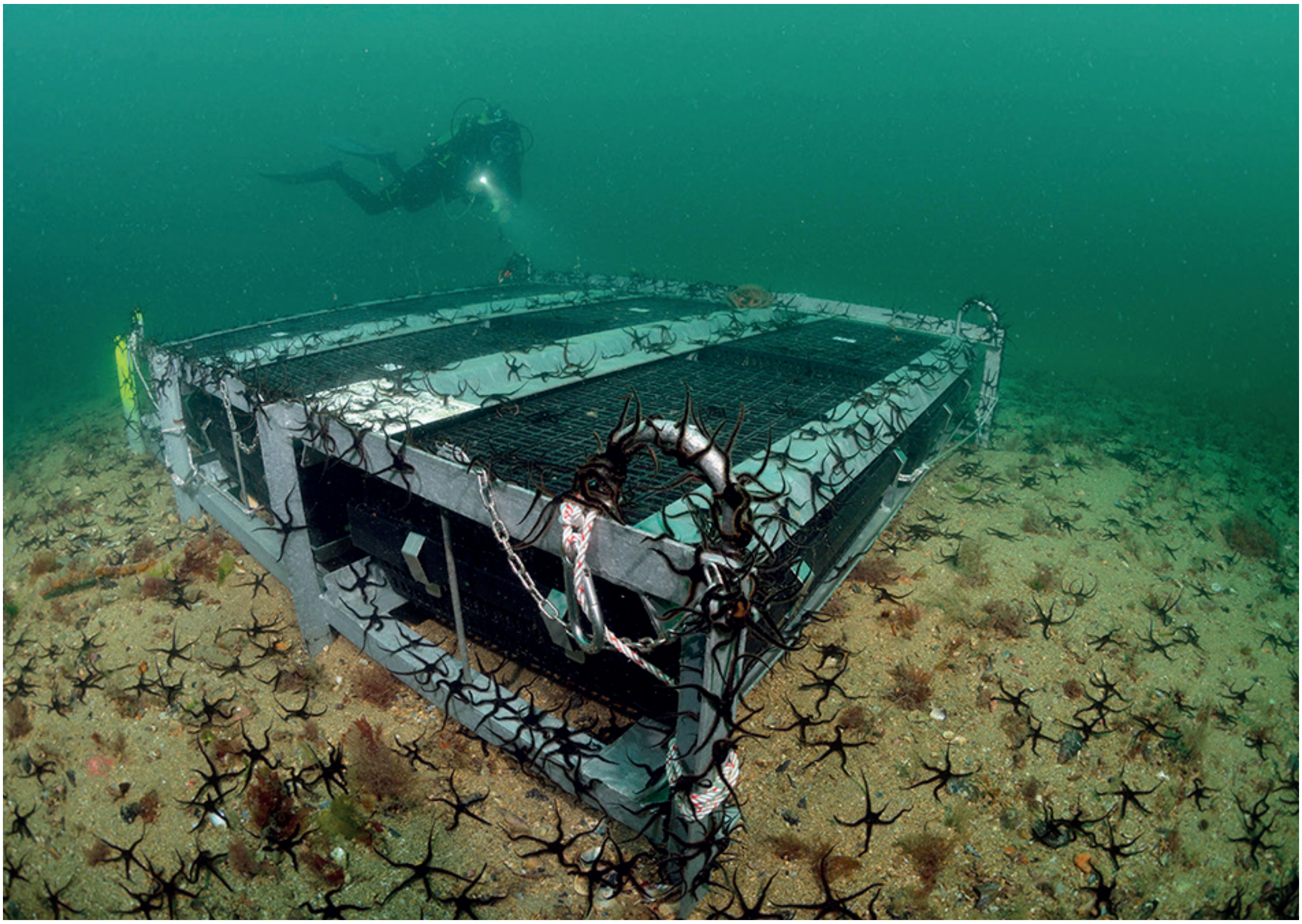

**Figure 1.** Submerged devices to study the growth of black brittle stars (*Ophiocomina nigra*), © O. Dugornay/IFREMER-2014. https://image.ifremer.fr/data/00737/84926/

from recreational diving agencies. In several countries, Occupational Scientific Diving must be recognized by law in order to be used as a scientific technique by professionals. This aspect becomes even more important when we consider the transnational mobility of scientists as part of collaborative research projects (Féral & Norro, 2023).

Indeed, the main concern is the mobility of scientists. To guarantee it, it is needed to set up an effective system of qualifications equivalence allowing mutual recognition that is, initial training level and controllable certificates issuance. The challenge was, and still is, the self-organization of the community of scientists using diving as a working tool inside the patchwork of very different legal situations existing among EU countries. The aim is the legal recognition of Occupational Scientific Diving and promulgation of compatible national laws (including fully compliant initial training standards).

## There is a need to define Occupational Scientific Diving and its standards

To be used in the legal literature of any country, any term must be clearly defined. However, this condition is currently not met. The term "scientific diving", widely used since the 1970s to describe the technique and the setting, has become extremely vague due to the considerable extension of the various situations in which it is used today. To stick to its original meaning, it was necessary to specify the occupational framework. In addition to its purpose, its definition specifies its framework, and also indicates which categories of population are concerned.

*Occupational Scientific Diving (OSD) is science-led diving and is needed to support professional research and education and protect, conserve, and monitor the natural and cultural heritage environment. Operated as a work activity, OSD is not to be confused with recreational nor commercial diving. OSD exists* *in a health and safety framework that involves certified occupational scientific divers, diving officers, hyperbaric physicians, scientific project leaders, heads of laboratories, administrators, and legislators.*

To enable and promote the mobility of diving scientists at least in Europe, there was a need to develop a reference system (standards) approved by as many countries as possible. Two levels were concerned (Féral & Norro, 2023):

- The national recognition of OSD as a tool was first supported by the EU program MAST III (Weydert, 1996). A unique reference system (ESD-European Scientific Diver and AESD-Advanced European Scientific Diver) (Table 1) was the major output of the European workshop supported by MAST III-sub-area D2 (EUR, 1996), held on the island of Elba (Abbiati, 1997).

- The transnational recognition was achieved when fifteen European countries approved these initial training standards (EU workshop, 2000, Banyuls-sur-Mer, France - Belgium, Finland, France, Germany, Greece, Ireland, Iceland, Italy, Netherlands, Norway, Poland, Portugal, Spain, Sweden, and United Kingdom).

Optimal visibility was achieved in 2008 when the *ad hoc* European Committee for Scientific Diving became a panel (ESDP-European Scientific Diving Panel) of the Marine Board (latter European Marine Board) under the umbrella of the European Science Foundation (Sayer et al., 2008; Féral, 2010 ; Féral & Norro, 2023). Representativeness is the most important in this kind of operation. The goal was achieved with the help of the Marine Board bringing together 35 organizations and consortia (major national marine research institutions and universities) from 18 countries representing the quasi totality of marine sciences in Europe (*cf*. Table 2 in Féral & Norro, 2023).

To qualify for either category of standards (ESD and AESD) (Table 1) concerned scientists must already be experienced divers. There are legal depth limits, 20 m and 30 m and beyond. The "advanced" level requires in addition underwater planning and leadership skills. work experience is also taken into account. These standards are designed for maximum efficiency and safety at work. Such standards are already linked with the laws of 7 European countries, potentially simplifying relations between them (Belgium, Finland, France, Germany, Norway, Sweden, United Kingdom). Scientific diving is also specifically recognized by Poland and Spain, although the terms and conditions for using OSD have not yet been defined by decree at the national level.

## Present situation in Europe

Sixteen European states and territories (Belgium, Bulgaria, Cyprus, Finland, France, Germany, Gibraltar, Greece, Italy, Netherlands, Norway, Poland, Portugal, Slovenia, Sweden, and United Kingdom) are currently (2023) members of the ESDP, at different levels, depending on the legal situation of OSD (Féral & Norro, 2023). The aim is not to create a rigid hierarchy, but to have a permanent description of the situation of occupational scientific diving, country by country, facilitating exchanges. Updates are made as soon as the information is verified. The evolution of the status of a country can go in both directions, as new national laws come into force or existing laws are abrogated.

## Is the present situation satisfying for science?

Compared with the 1970s, when difficulties were piling up on the scientific practice of diving, making it less and less practicable, we can see that progress has been made on many fronts. OSD strongly supports research in coastal waters (Cattaneo-Vietti & Mojetta, 2021). Minimum standards of competence are being incorporated into the laws of more and more countries in which quality of training is monitored and issuance of certificates of competence is controlled. Minimum standards may be recognized and enforced despite the absence of legal requirements to do so in other countries. Mobility of scientists is increasing. However, things remain difficult overall. National legal situations are so tough that some countries are abandoning their efforts because of the excessive administrative and legal complexity. This is a first type of serious obstacle to the practice of OSD and to the mobility of scientists in Europe.

In addition to the OSD legal status, another obstacle of an entirely different nature is the ever-increasing need for quality-controlled data, particularly in the field of ecology and the environment. Above this, there is an ever-increasing need for underwater data, due to the ever-larger spatial scale of investigations and monitoring and to the need of collecting data over a longer time scale. There is a need for much more underwater manpower, which the OSD sector cannot meet alone. If local studies give insights on species and community functioning, it is shown that identified local factors may collapse when re-evaluated at a regional scale (Webb et al., 2009). Data at regional and global scales are now recognized as fundamental to progresses in ecology (Kerr et al., 2007) including the role of Citizen Science (Pecl et al., 2019).

**Table 1.** Main competency requirements for the European and Advanced European Scientific Diver standards). All evidence must be recorded in nationally acceptable logs, countersigned by suitably qualified persons/authorities.

| European Scientific Diver (ESD) | Advanced European Scientific Diver (AESD) |
|---|---|
| A **ESD** is a diver capable of ***acting as a member of*** a scientific diving team. | A **AESD** is a diver capable of ***organising*** a scientific diving team. |
| - show proof of ***basic*** theoretical knowledge and a ***basic*** understanding of: | - show proof of theoretical knowledge and a ***comprehensive*** understanding of: |
| 1. diving physics and physiology, the causes and effects of diving-related illnesses and disorders and their management | 1. diving physics and physiology, the causes and effects of diving-related illnesses and disorders and their management |
| 2. the specific problems associated with diving to and beyond ***20 m***, calculations of air requirements, correct use of decompression tables, | 2. the specific problems associated with diving to and beyond ***30m***, calculations of air requirements, correct use of decompression tables, |
| 3. equipment, including personal dive computers and guidelines as to their safe use, | 3. equipment, including personal dive computers and guidelines as to their safe use, |
| 4. emergency procedures and diving casualty management, | 4. emergency procedures and diving casualty management, |
| 5. principles of dive planning, | 5. principles and practices of dive planning and the selection and assessment of divers, |
| 6. legal aspects and responsibilities relevant to scientific diving in Europe and elsewhere. | 6. legal aspects and responsibilities relevant to scientific diving in Europe and elsewhere, |
| | 7. dive project planning. |
| - be fully competent with/in: | *- be fully competent with/in:* |
| 1. diving first aid, including cardio-pulmonary resuscitation (CPR) and oxygen administration to diving casualties, | 1. *diving first aid, including cardio-pulmonary resuscitation (CPR) and oxygen administration to diving casualties,* |
| 2. SCUBA rescue techniques and management of casualties, | 2. *SCUBA rescue techniques and management of casualties,* |
| 3. the use and user maintenance of appropriate SCUBA diving equipment. | 3. *the use and user maintenance of appropriate SCUBA diving equipment* ***including dry suits and full-face masks,*** |
| | 4. ***basic small boat handling and electronic navigation,*** |
| | 5. *supervision of diving operations.* |
| - be fully competent with: | - be fully competent with: |
| 1. search methods, | 1. search methods, ***such as those utilizing free-swimming and towed divers together with remote methods suitable for a various range of surface and sub-surface situations,*** |
| 2. survey methods, both surface and subsurface, capable of accurately locating and marking objects and sites, | 2. survey methods, both surface and sub-surface, capable of accurately locating and marking objects and sites, |
| 3. the basic use of airbags and airlifts for controlled lifts, excavations, and sampling, | 3. the basic use of airbags and airlifts for controlled lifts, excavations, and sampling, |
| 4. basic rigging and rope work, including the construction and deployment of transects and search grids, | 4. basic rigging and rope work, including the construction and deployment of transects and search grids, |
| 5. underwater navigation methods using suitable techniques, | 5. underwater navigation methods using suitable techniques, |
| 6. recording techniques, | 6. recording techniques, |
| 7. ***acting as surface tender for a roped diver,*** | 7. ***roped/tethered diver techniques and various types of underwater communication systems such as those utilizing visual, aural, physical, and electronic methods,*** |
| 8. sampling techniques appropriate to the scientific discipline being pursued. | 8. sampling techniques appropriate to the scientific discipline being pursued. |
| - show proof of having undertaken ***70*** open-water dives to include a minimum of: | - show proof of having undertaken ***100*** open-water dives to include a minimum of: |
| 1. ***20*** dives with a scientific task of work such as listed above, | 1. ***50*** dives with a scientific task of work such as listed above, |
| 2. ***15*** dives between ***15 and 24 m,*** | 2. ***20*** dives between ***20 and 29 m,*** |
| 3. ***5*** dives ***deeper than 25 m,*** | 3. ***10*** dives ***between 29 m and the national limit,*** |
| 4. ***12*** dives in the last ***12*** months, including at least ***6*** with a scientific task of work | 4. ***12*** dives in the last ***12*** months, including at least ***6*** with a scientific task of work |
| | 5. ***20 dives in adverse conditions such as currents, cold or moving water***, |
| | 6. ***20 dives as an in-water dive leader*** |

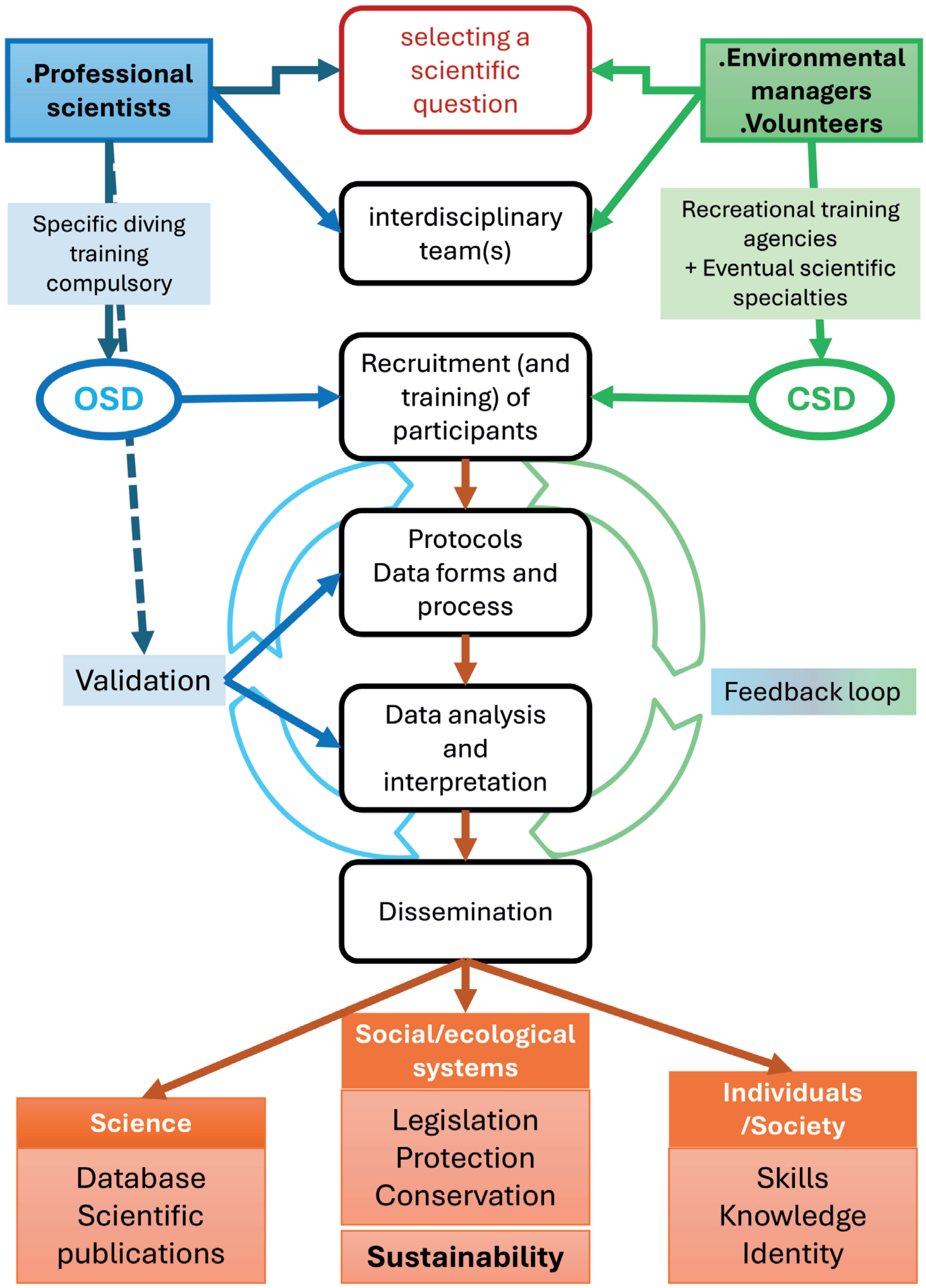


**Figure 2.** Example of roles and operational links between occupational (OSD) and citizen (CSD) scientific diving. Cross-integrated actions between OSD and CSD make possible a feedback loop propelling research and monitoring subaquatic ecosystem (healthy or under anthropogenic pressure). Roles of the different qualifications of the scientific diver (occupational *vs*. recreational) are distributed depending on their actual scientific background, technical skill, training, and time to devote to science. Scientists identify and define the scientific question(s) to be addressed and develop the necessary protocols (underwater tasks successions and data collection, processing and management). After being tested by occupational scientific divers, the protocols, simplified if and where needed, are validated for implementation by the citizen scientific divers. He/she is specifically trained for that particular project before its start. The collaboration of volunteer divers is increasingly essential, given the growing need for data over larger areas and more extended periods. Outcomes resulting from these collaborations concern both the scientific disciplines involved and the social and environmental management systems, leading to greater sustainability. At both individual (scientists and volunteers) and societal levels, the outcomes relate to increased skills and knowledge. They can also highlight a site or an environment, which will help to create or consolidate a local/regional/national identity.

## The essential role of Citizen Science Diving (CSD)

Citizen Science has numerous aliases (amateur science, community science, crowd science, crowd-sourced science, civic science, volunteer monitoring) reflecting different perceptions. All definitions insist on the involvement of the non-academic and free willing public participation: *Citizen Science is the involvement of the non-academic public in the process of scientific research - whether community-driven research or global investigations* (BioDiversa⁺ [European network of national programmers and funders of research on biodiversity, ecosystem services and Nature-based Solutions], reported by Goudeseune et al., 2020). In this context, Citizen Science Diving (CSD) is defined as diving carried out within a specific scientific project framework by qualified amateur divers. This approach optimises efficiency by increasing the amount of quality-controlled data that can be collected. Academic Science is increasingly aware of the very positive aspect of the potential contribution of “marine” Citizen Science and the interest in feedback loops between volunteers, society, and professional scientists (Garcia-Soto et al., 2021), even if diving presently concerns only a relatively small proportion of the actions. Coastal habitats are the most under anthropogenic pressure but also the most accessible. Thiel et al. (2014, *cf.* Fig. 4) illustrated the relative proportions of Citizen Science studies relating to different marine areas. About 30% of studied habitats by marine citizen scientists are subtidal areas easy to reach using SCUBA/CCR diving and this helps the conscientisation of a broad public. Nevertheless, there is a clear benefit to science of further development of Citizen Science projects. In this frame, the training of volunteer recreational divers in scientific specialities (e.g. marine biology or oceanology certifications, etc.) as organized by recreational diving agencies (CMAS-World Underwater Federation, GUE-Global Underwater Explorers, PADI-Professional Association of Diving Instructors, …) that qualify Citizen Science divers is an added value. However, it should be kept in mind that the legal framework [risk assessment, insurance, policy, employer constraints], the objectives, the actors, and the audience are *de facto* different from OSD.

## The consequences of a semantic drift

Nowadays, the generic term ”Scientific Diver” for all individuals diving ”at large” for science is in use and creates confusion (ScienceDiver, 2018). The result is a blurred landscape between professional scientists diving in the framework of national laws and health and safety regulations at work (OSD) and volunteer recreational divers active in Citizen Science projects (CSD). In the long term, this confusion could cause countries that have legalised OSD to go backwards (through loss of confidence) linked to increased accident rates (Dardeau et al., 2012). It also hinders other countries from creating the necessary legislation. The situation could be exacerbated by the generalisation of new, less restrictive sets of ISO standards for scientific diving (ISO Technical Committee 228: Tourism and related services, Working Group 1: diving services). Those standards do not apply to the professional sector. Moreover, it is hard to see the progress in creating a parallel system to replace tested and agreed occupational standards already included in the laws of several EU Member States.

## What do environmental managers need?

The availability of ecological data at regional and global scales is a necessary aid to management in many areas (Edgar et al., 2016). Increasing the spatial and temporal scales of investigations and monitoring to meet the ever-growing need for reliable data is difficult to satisfy. It is all the more difficult in the marine environment, because the threats are out of sight, under-mapped, cumulative, and often poorly understood, generating inefficiently managed impacts. This need for abundant, high-quality data requires protocols and processes adapted to scientific analyses. That means that a simple “scientific diving label“, obtained for life, in some days or weeks through recreational diving agencies (CMAS, GUE, PADI, etc.) is not enough. To be effective, any action must be integrated into a coordinated project, defining protocols, collecting data, and quality control of both. Each actor, professional or amateur scientist, must play a different and defined role in the right place, according to their real (technical and scientific) skills (Tweddle et al., 2012; Pocock et al., 2014; Hermoso et al., 2019). Environmental managers have also adopted the multi-scale paradigm of ecosystem processes, as threats to marine biodiversity are generally globally distributed, interactive and non-linear. A large part of the solution concerns Citizen Science, particularly Citizen Scientific Diving (Edgar et al., 2016). It must organize itself (in connection with academic scientists) from data collection to processing and dissemination to the environmental management decision-making bodies. Figure 2 illustrates how the various phases of an environmental project involving professional scientists and amateurs can be structured. Each diver will be involved according to his or her experience and technical skills to serve a particular aspect of the project.

## Place of OSD in the Blue Economy

As soon as an underwater action takes place, it is hard not to relate it to the increasingly essential concept of "Blue Economy". As with “scientific diving”, we are dealing with another umbrella term with different meanings: (1) the overall contribution of oceans to economies, (2) the need to address the environmental and ecological sustainability of oceans, and (3) the ocean economy as a growth opportunity for both developed and developing countries (Center for the Blue Economy, CA, USA). Broad themes such as sustainable supply chain and consumer offering sustainability or sustainable experiences and Citizen Science opportunities may be highlighted. Given its current expansion, diving naturally falls within the definition of this economy. These include dive tourism and dive fisheries (Nisa, 2022 ; Forrest et al., 2023). In some countries, dive tourism generates incomes comparable to industrial fishing (Forrest et al., 2023). It has to be said, however, that the scientific aspect is mainly a marketing element, even though diving is considered to represent one of the only endeavours that enables citizens to support the Blue Economy actively. This is true, of course, especially if the citizen action is truly framed within a program that can produce sustainable results in environmental management and thus contribute to achieving conservation and sustainable development objectives. It is thus clear that it is not necessary to ignore its specificity and its inescapable aspect for OSD to be integrated into this vision of the environment. On the contrary, each element must be clearly defined for greater performance as for a clear legal and liability framework.

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