FACULTAD DE CIENCIAS DEL MAR

UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA

SCIENTIFIC DIVING IN THE MONITORING OF COASTAL ECOSYSTEMS

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Curso 2017/2018

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Master in Management of Fisheries Resources

The Diving Scientific in the Monitoring of the Coastal Ecosystems

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Las Palmas de Gran Canaria June 28, 2018

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Abstract

Scientific diving has become a tool for knowledge of the sea due to the advancement of autonomous diving technologies that have given greater independence to the diver, with the ability to be much longer in the bottom and observe the underwater ecosystems, its biocenosis and the behavior of the species.

The international scientific community through the different international organizations recognizes scientific diving as a necessary tool for scientific research, arriving to define both the scientific diving as the scientific diver and the scientific team among others.

Unesco, like other organizations, publishes manuals together with **CMAS!** (**CMAS!**) on the ethics and behavior of the scientific diver in the marine environment, as well as safety standards in scientific diving.

This causes that said diving activity to be considered as different from professional diving and recreational sports diving. The decree of the Ministry of Public Works of 1997 on safety standards in diving established that it should follow the rules of professional diving, so that signatures were collected in all Spanish universities and research centers to modify it. In 2000 a decree was published modifying in part the safety rules in diving and introducing the figure of the scientific diver, this regulation is still in force at the moment.

Currently, a new regulation has been proposed and the Ministry of Development has opened a period of consultations on it for its review and publication.

With the publication of the European directives on water quality and the protection of the marine environment and its implementation and implementation in Spain, the need to have a very large group of scientific divers that meet the multiple needs of monitoring has been highlighted. evaluate the environmental status of submerged ecosystems and take all the parameters required by the directives.

The necessary work techniques for this monitoring are exposed, from the organization of the campaigns to the taking of data, evaluating the need of the realization of courses that cover the needs of training in scientific diving. These courses certify the knowledge of the marine environment, work techniques and safety in diving. Some organizations such as ac CMAS grant degrees recognized by Unesco.

Nowadays courses are given in many national and international universities, as well as many international organizations accredit courses of scientific divers, pointing out the requirements of content, all of them have in common not only the knowledge on the underwater scientific activity but on the security in the practice of scientific diving.

These titles are valid in many countries, being able to be hired and to practice as scientific divers, giving a more exit to the future graduates of the different races dedicated to the marine environment.

The subjects taught in these courses are varied and comprehensive trying to cover all about the marine environment, such as: Biology, Ecology, Physics, Physiopathology, Statistics, Archeology, Installation of measuring equipment, Photography, Video, First Aid, Rescue, Legislation , Coordination of campaigns, Security rules, etc.

Resumen

El buceo científico se ha convertido en una herramienta para el conocimiento del mar debido al avance de las tecnologías de buceo autónomo que han dado una mayor independencia al buceador, con la capacidad de poder estar mucho más tiempo en el fondo y observar los ecosistemas sumergidos, su biocenosis y el comportamiento de las especies.

La comunidad científica internacional a través de las distintas organizaciones internacionales reconoce el buceo científico como una herramienta necesaria para la investigación científica, llegándola a definir tanto el buceo científico como al buceador científico y al equipo científico entre otros.

La Unesco al igual que otras organizaciones editan manuales conjuntamente con CMAS sobre la ética y el comportamiento del buceador científico en el medio marino, así como los estándares de seguridad en el buceo científico.

Esto hace que se planteara dicha actividad de buceo como diferente del buceo profesional y el buceo deportivo recreativo. El decreto del Ministerio de Fomento de 1997 sobre las normas de seguridad en el buceo estableció que debía seguir la normativa del buceo profesional, por lo que se recogieron firmas en todas las universidades y centros de investigación españoles para modificarlo. En el año 2000 se publicó un decreto modificando en parte las normas de seguridad en el buceo e introduciendo la figura del buceador científico, esta normativa sigue en vigor actualmente.

Actualmente se ha propuesto una nueva normativa y el Ministerio de Fomento ha abierto un periodo de consultas sobre la misma para su revisión y publicación.

Con la publicación de la directivas europeas de calidad de aguas y de protección del medio marino y su implantación e implementación en España, se ha puesto de manifiesto la necesidad de contar con un grupo muy amplio de buceadores científicos que atiendan la múltiples necesidades de monitorización para evaluar el estado ambiental de los ecosistemas sumergidos y tomen todos los parámetros que exigen las directivas.

Se exponen las técnicas de trabajo necesarias para esta monitorización, desde la organización de las campañas hasta la toma de datos, evaluando la necesidad de la realización de cursos que cubran las necesidades de formación en buceo científico. Estos cursos acreditan el conocimiento del medio marino, técnicas de trabajo y seguridad en el buceo. Algunas organizaciones como CMAS otorgan títulos reconocidos por la Unesco.

Hoy día se imparten cursos en muchas universidades nacionales e internacionales, así como muchísimas organizaciones internacionales acreditan cursos de buceadores científico, señalando los requisitos de contenido, todos ellos tienen en común no solo el conocimiento sobre la actividad científica subacuática si no sobre la seguridad en la práctica del buceo científico.

Las materias impartidas en estos cursos son variadas y amplias intentando cubrir todos los conocimientos sobre el medio marino, como: Biología, Ecología, Física, Fisiopatología, Estadística, Arqueología, Instalación de equipos de medición, Fotografía, Vídeo, Primeros auxilios, Rescate, Legislación, Coordinación de campañas, Normas de seguridad, etc.

Estos títulos tienen validez en muchos países, pudiendo ser contratados y ejercer como buceadores científicos, dando una salida más a los futuros titulados de las diferentes carreras dedicadas al medio marino.

The subjects taught in these courses are varied and comprehensive trying to cover all knowledge about the marine environment, such as: Biology, Ecology, Physics, Physiopathology, Statistics, Archeology, Installation of measuring equipment, Photography, Video, First Aid, Rescue, Legislation , Coordination of campaigns, Security rules, etc.

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Acronyms

AAUS America Academy of Underwater Sciences

ACUC America Certification Underwater Candian

ANECA National Agency for the Evaluation of Quality and Accreditation

GES Good Environmental Status

CAUS Canadian Association for Underwater Science

CE European Community

CMAS World Confederation of Underwater Activities

CR Red Cross

ESDP European Scientific Diving Panel

FP Professional Training

GEAS Special Group of Underwater Activities

GPS Global Positioning System

IDEA International Diving Educators Association

IEO Spanish Institute of Oceanography

IANTD International Association of Nitrox and Technical Divers

MF Ministerio de Fomento

NAUI National Association of Underwater Instructors

NOAA National Oceanic and Atmospheric Administration

OAG Granadilla Environmental Observatory

PADI Professional Association of Diving Instructors

PIO Depth Inclination Orientation

PROMAR European Directives on Water and Protection of the Marine Environment

PROTEC CMAS International Organization

PVC Vinyl Polychloride

RAE Real Academia Española

ROV Remote Operated Vehícle

SSI Scuba Schools International

TFM Final Master's Project

UNESCO United Nations Educational, Scientific and Cultural Organization

EU European Union

1 Introduction

This work is aimed at the development of scientific activity in the underwater environment, more specifically in the sub-tidal zone between 3 and 60 m depth, for the realization of these research studies is used as a tool scientific diving.

1.0.1 Definition of Diving and Scientific Diver

According to the Real Academia Española (RAE) there is no definition of scientific diver, nor does it exist for the (professional diver) or the (recreational sports diver). But if there are the terms diver or scuba diver (diving), diving (swimming with the whole body submerged, working as a diver, exploring about some material or moral issue). It also defines the RAE the term submariner as a person who practices scuba diving, pertaining or relative to diving, individual of the Navy specialized in the service of submarines and, finally, we find the definition of diving as the set of activities that they are carried out under the surface of the sea, for scientific, sporting, military purposes, etc.

While other diving organizations define it in the following way:

The Granadilla Environmental Observatory (OAG), defines it as: All that immersion in the hyperbaric environment derived from a scientific research activity, including ecological monitoring.

The America Academy of Underwater Sciences (AAUS), as: (Scientific diving is defined (29CFR1910.402) as diving required only a necessary part of a scientific, research, or educational activity by whose sole purpose is to perform scientific research tasks) , "Diving performed only as a necessary part of scientists, research, or educational activity, whose exclusive objective is to perform immersion as scientific research tasks".

The CMAS, such as "diving executed by individuals, necessary or as part of a scientific investigation or educational activity of a project or study, carried out under the jurisdiction of an educational or public or private research institution, or similar organization".

European Scientific Diving Panel (ESDP) points out that the scientific diver is a diver capable of acting as a member of a scientific diving team. He or she can achieve this level either by a course or in the field of training and experience, under appropriate supervision or by a combination of these two methods.

Although there is some differentiating nuance in the previous definitions, these are insignificant, confirming all the definitions that scientific diving is an activity developed in a hyperbaric environment in order to carry out scientific research.

Then you could define the scientific diver as a scientist who develops his activity under the surface of the sea using diving as a work tool.

Underwater scientific activity is carried out in all countries of the world, as shown by the different articles published in the different scientific journals [34], the use of this sampling system can be seen perfectly in the published articles [12].

Organizations have considered and demonstrate their standards and regulations to scientific diving as a useful tool, without which the underwater research activity would not be fully developed by not being able to verify in-situ the biological processes that occur in nature.

Scientific diving has evolved along with professional diving and recreational sports diving. By improving its techniques and equipment, it has also improved safety in scientific diving, as well as in sampling techniques. We must not forget that the scientific diver performs scientific underwater work after all, this work is not free of risks and dangers, being the diver subject at all times to the current legislation and the safety regulations of each country.

Through scientific diving we have been able to make in-situ observations and measurements, with these techniques we have been able to obtain accurate and detailed information of the phenomena that occur in submerged marine or freshwater environmental conditions, as well as observations in the environment that would otherwise not it would have been possible to acquire without the proper techniques [20].

These techniques are published over the years in different manuals of different international organizations dedicated in part to scientific diving, their validity today are no longer discussed as they have served as tools in marine research [29].

United Nations Educational, Scientific and Cultural Organization (UNESCO), with the support of the CMAS, created the ethical code for scientific diving practices, with the aim of offering guidance when carrying out underwater research work safely, this was possible thanks to the collaboration of experts and experienced scientists who have been developing this activity for years as scientific divers [37]

1.0.2 Purpose of Scientific Diving

Scientific diving is aimed at marine observation, conducting trials and experiments or scientific research, being practiced by scientists or scientific research teams, whether these students, research technicians, university professors, doctors linked to work groups, centers of research, research institutes or universities.

The need to improve the knowledge of the marine environment and therefore the application of scientific diving has been an objective of interest, international organizations such as: AAUS, CMAS, UNESCO, National Oceanic and Atmospheric Administration (NOAA), Canadian Association for Underwater Science (CAUS) among others, have highlighted the importance of scientific diving, this is a useful tool for studies and conservation of marine ecosystems, particularly coastal ecosystems [28].

Scientific diving can be applied in many areas of knowledge and scientific disciplines such as: Biology, Geology, Chemistry, Archeology, Oceanography, etc., This can be put into practice in studies of environmental impacts, monitoring programs and ecosystem description marine, inventories of species, study and conservation of biodiversity, etc.

Many of these processes can be recreated in laboratories and aquariums, although not all will have the suitability conditions for the research process to obtain the expected results, having to carry out such experiments in the marine environment.

For the realization of such work requires professional qualification as a researcher and knowledge in scientific diving techniques, for this purpose courses are taught where these sampling techniques are taught, the use of tools for the proper development of the work and the security plans.

Safety will always be the most important in all work carried out in a hyperbaric environment, since it is often worked in conditions of little or no visibility, with normally low water temperatures, with frequent surface and submarine currents, with outside temperatures high, where the time indicated for the performance of the work is given by the depth at which the work is developed, the air consumption and the saturation of the nitrogen in tissue tissues.

1.0.3 objective of the work

The present work has several objectives, one of the objective is to make a revision of the Spanish legislation, both state and autonomous, of the regulation of scientific diving. The implementation of the European Directives on Water and Protection of the Marine Environment (PROMAR) has established the needs of wide monitoring of marine and coastal ecosystems, as well as the protection of the marine environment and its water, which are mandatory for the EC countries.

Another objective of the present work is to analyze the necessary requirements in all aspects for the realization of underwater work campaigns, for this it is necessary to have knowledge about the different sampling techniques to be carried out in underwater work.

to show the different categories and responsibilities existing in underwater research campaigns, the functions that each one has and the responsibility within the work team.

The review of the different publications and learning techniques in scientific diving, as well as the manuals and guides published by the different international or national organizations dedicated to marine research.

Among the objectives we will analyze the different courses that are taught internationally and nationally, the curricula, the objectives pursued by these courses and the validity of the courses carried out by the different organizations.

2 Material and Method

As this is a documentation work, the methodology used for its development it has been the consultation of the bibliographic sources, such as: books, notes, end-of-degree projects, final master's projects and the articles related to the Master's thesis.

The library of the Faculty of Marine Sciences, have been one of the sources that I have used to obtain documentation, as well as the computer networks available in the Faculty of Marine Sciences and the Department of Biology.

These computer networks have helped me to obtain information on legislation, and different publications such as: articles, books, press releases, etc., in our case, is the most appropriate tool for the implementation of Final Master's Project (TFM).

The consultations were made through commercial programs such as: Safari and Google Chrome among others.

The equipment used to perform this search has been my personal computers, specifically the 27-inch Imac last generation, a MacBook, with 1.7 Ghz Intel Core 15 processor with a memory of 4 GB 1600 MHz DDR3 and a Macintosh boot disk Hd, Hewlett-Packard 3300 prink HP printer and a 1T external hard drive that helps us store the information found related to the ac TFM.

Among the different programs used are those of the Microsoft Offier package, (Work, Excell, Power Point), Adobe Photoshop for image processing.

We used a text composition system, oriented to the creation of written documents that have a high typographic quality. Due to its characteristics and possibilities, it is used especially intensively in the generation of articles and scientific books that include, among other elements, mathematical expressions, tables, chapters, sections, subsections and annexes.

LaTeX consists of a large set of TeX macros, written by Leslie Lamport in 1984, with the intention of facilitating the use, created by Donald Knuth.

3 Result

3.1 Legal situation of Scientific Diving

Some countries have been developing regulations or legislations that regulate scientific underwater activity, as well as the delivery of courses that have been organized through public or private universities, private diving centers and national or international diving organizations. But all these regulations have a common purpose, that of establishing norms that contribute to greater security and preservation of the lives of people who practice this activity as a work tool.

The scientific diving is given by the increase of the experiences in R D that the public and private organisms had been doing in the hyperbaric environment, where it became clear that the activities related to scientific diving could not be included within the characteristics that they were used for professional diving, but it was necessary to take into account the existing reality, that the researchers developed scientific activities in aquatic environments and that therefore it was necessary to have an imperious legislation independent of the legislation applied to professional diving or recreational-sports.

3.1.1 Legal Situation of Scientific Diving in Spain

In Spain, scientific diving was regulated after a legal vacuum for two years by the ORDER of October 14, 1997, which approves the safety regulations for the exercise of underwater activities of the Ministry of Development, in this decree only mentions scientific diving in Article 10 to demand a professional title for their practice .ᴬrticle 10 Diving in freediving 1. The practice of diving in freediving for work, professional or scientific purposes, will require that the diver have some professional diving certification"[26].

This Order is strongly contested by universities and research centers since it made underwater research conditional on obtaining a Professional Training (FP). This was modified by the Order of July 20, 2000 and published in BOE No. 188 of August 7, 2000 where it regulates "The scientific team participating in scientific research projects developed by public or private research organizations, will be applicable the safety rules of recreational diving - recreational [27].

It includes in the decree that corrects these three definitions:

- Scientific diving: All that immersion in the hyperbaric environment derived from a scientific research activity.
- Scientific team: Group of people who perform immersions in a hyperbaric environment, for the realization of a study or specific scientific project duly authorized.
- Auxiliary personnel: Any diver who is not part of the scientific team, but who is necessary for the development of the activity.

This correction to the 1997 Decree was implicitly accepted by scientific divers, and it was not until the end of 2016 that the Resolution of October 18, 2016, of the General Directorate of Employment was published, whereby the Act is registered and published. of the agreement to modify the collective agreement for professional diving and hyperbaric means and the agreement on safety standards in underwater activities.

In this resolution, scientific diving is reintroduced into professional diving, "Prohibition of autonomous diving for any professional or scientific diving operation included in this agreement, except in cases of teaching and only with students who have not yet been titled"[25].

The response of Ministerio de Fomento (MF) to a consultation of the Montgó natural park dated January 30, 2017 regarding the application of this Resolution, says that "scientific diving done from research institutes and universities is still regulated by the Order of July 20, 2000 (BOE of August 7) by modifying the safety regulations for the exercise of underwater activities, approved by Order of October 14, 1997. This order follows the rules of sports diving for the scientific diving, not having been repealed by the new resolution of 2017, so it would remain in force".

This has reopened the debate and is currently proposed by the MF a draft Royal Decree "by which the safety conditions of diving activities in Spanish maritime waters are determined"that has opened a period of public consultation [41].

This project establishes within the modalities of diving in its article 3 section D "Scientific diving: it is the one whose purpose is to carry out studies or projects linked to a scientific research activity".

Chapter III section 4 gives the safety rules for scientific diving.

Article 51. Security rules applicable to scientific diving.

The rules of recreational diving will be applicable to scientific diving activities, provided that the dives do not exceed 40 meters deep, no scheduled decompression stops are made and that during the development of the operations only use manual tools.

For diving operations that exceed the limits established above, the professional diving rules will apply.

To the auxiliary personnel not belonging to the scientific team and whose intervention is necessary for the development of the diving operation, the rules for professional diving will be applicable in any case.

Currently there are several groups that have submitted proposals that, in summary, go in two different ways:

- Do not consider scientific diving as a form of diving, being able to dive each researcher according to their level of qualification both recreational-sporting and professional.
- Consider it as a diving modality and regulate it more widely with a differentiated diving from the other modalities, particularly sports-recreational and professional diving. For which you should establish your own regulations and courses.

3.1.2 Legal Situation of Scientific Diving in the Canary Islands

Canarias currently has the competences for the regulation of professional diving in the area of its territory, through Decree 19/1999, of January 29. The Ministry of Agriculture, Fisheries and Food, published Decree 88/2008, of April 29, which establishes the conditions that enable the practice of professional diving in the Autonomous Community of the Canary Islands and authorization to centers that wish teach courses for obtaining professional diving certificates (published in BOC No. 95 of May 13, 2008).

This decree established in article 7.1.1 the competences of basic professional diver and its attributions, and defines that "Basic underwater work is understood as those tasks that require the use of simple manual and mechanical tools, it can also include related tasks with sampling, counting and lifting of plans, as well as underwater rescue and assistance.

With this, scientific divers need a professional degree to carry out their activity in the Canary Islands, in this sense the Vice-Ministry of Environment of the Canary Islands Government has addressed in June 2017 the Vice-Ministry of the Primary Sector of the Ministry of Agriculture, Fisheries and Food, clarifying that "the fact of exercising scientific or technical activity is a professional activity, which may involve the use of diving equipment, this being a means for its development, not a professional activity in itself". Explains that the difference between scientific / technical diving (performed by scientists, graduates and technicians of environmental administrations or consultancies) and professional scientific diving (performed by professionals who perform their own tasks or accompany scientific divers in the framework of work, studies or projects).

Accompany the writing with the mention to regional legislations where they have the diving competitions (Andalucía, Pais Vasco and Valencia) where for the realization of scientific diving a recreational diver title is necessary.

They conclude by requesting "the modification of the regulations, so that the scientific-technical diving, that carried out within the scientific activity of research centers, the consultancy of the companies and that of the technicians of the regional administration, can be carried out with Recreational diving licenses. "This request has not yet been answered by the vice-ministry of Agriculture, Fisheries and Food [39].

This request has not yet been answered.

3.2 Legal Requirement for Ecosystem Monitoring

Spain has 5,849 km of coastline, divided between the peninsular coastline, the Canary Islands, the Balearic Islands, Ceuta and Melilla. The Canary Islands has 1,126 km of coastline, this is 19.2 % of the total Spanish coasts, where almost 300 km of coastline are now marine reserves, equivalent to 5.1 % of total coasts Spanish and 26.6 % of the Canary coasts [16], along this coast, both technical and scientific research work, monitoring programs of marine ecosystems are carried out, environmental impacts, description of ecosystems, identification of species. It is important to highlight the underwater ecological monitoring needs that have become mandatory due to the publication and entry into force of the European Directives [30].

Figura 3.1: https://www.educa2.madrid.org/web/adiaz2/las-costas-peninsulares-espanolas

In the year 2000 the European Parliament establishes the Directive2000/60 / CE of the European Parlament And Of The Council, of 23 October 2000 by which establishes a community frame of performance in the field of the politics of waters . This directive (mandatory for all EC states) is aimed at maintaining and improving the quality of waters not only terrestrial but coastal, including them in river basins [9].

Defines as çoastal waters"the surface waters located towards land from a line whose totality of points is at a distance of one nautical mile offshore from the nearest point of the baseline that serves to measure the width of the territorial waters and extending, where appropriate, to the outer limit of transitional waters .ªnd as transitional waters"surface water bodies near the mouths of rivers that are partially saline as a consequence of their proximity to coastal waters, but that receive a remarkable influence of fresh water flows ".

A series of quality parameters are established that can only be evaluated with scientific diving techniques:

Indicators of ecological quality of coastal waters:

1° .- Macroalgae and angiosperms controls every 6 months

2° .- Benthic invertebrate fauna including macroinvertebrates with controls every 3 years

3° .- Fishes with controls every 3 years

The European Community (CE) in June 2008 was published the Framework Directive on the marine strategy known as PROMAR (Directive 2008/56 / EC of the European Parliament and of the Council of June 17, 2008) by which a framework of community action for the policy of the marine environment is established, Law 41/2010, of December 29, on the protection of the marine environment is the transfer to the Spanish legislation of the directive.

The main objective is to achieve or maintain a good environmental status of the marine environment no later than 2020. To do this, marine strategies are created as a tool for planning the marine environment.

Marine strategies consist of a series of consecutive tasks:

1° .- The initial assessment of the state of the marine environment.

2° .- The determination of good environmental status Good Environmental Status (GES)

3° .- The establishment of a series of environmental objectives in order to guide the process towards achieving good environmental status GES (carried out in 2012 the three phases).

4° .- The establishment of monitoring programs (2015) and the development and implementation of a program of measures to achieve good environmental status GES (2016).

This Royal Decree is an obligation derived from the provisions of Article 15 of Law 41/2010, of December 29, on the protection of the marine environment, being repealed by decision (EU) 2017/848 of the Commission by which establish the criteria and methodological standards applicable to the GES of marine waters, as well as specifications and standardized methods of monitoring and evaluation [7].

A series of monitoring subprograms are established that must be executed by the Autonomous Communities with competence and remit the data annually to the Secretary of State for the Environment for its insertion in a permanent database that allows the continuous evaluation of the environmental status of the ecosystems. coastal, we indicate below only the sections that may need for scientific data diving [24].

1.- Subprogram PC.1. Fish and cephalopod infralitic funds

2.- Subprograma HB.1 Infralittoral rocky habitats

3.- Sub-program HB.2 Infralittoral sedimentary habitats

4.- Subprograma HB.3 Circalitoral and batial rocky habitats

5.- Subprogram HB.4 Circumittoral and batial sedimentary habitats

6.- Sub-program HB.5 Intertidal and infralittoral habitats of marine angiosperms

7.- Subprogram HB.6 Protected benthic species

8.- Sub-program HB.7 Intertidal habitats (rocky and sedimentary)

9.- EAI.1 EMPs Specific monitoring subprograms for the detection and quantification of allochthonous species in marine protected or sensitive areas

10.- Subprogram EAI.2. Areas of risk: Sampling subprograms for the detection of alien species in areas of high risk of introduction (ports, aquaculture plants)

11.- Subprogram EAI.3. Invasoras: Specific subprograms for the monitoring of invasive aliens

12.- Subprogram EAI.4 "DATA MINING.ºf biodiversity programs and information management

13.- Subprogram EAI.5. Additional data

In all these subprograms we must report the data annually, these data include a very broad set of parameters that have variations for each subprogram, but we can summarize in the following points:

1.- Abundance (biomass)

2.- Abundance (coverage)

3.- Abundance (density of species)

4.- Abundance (number of species)

5.- Abundance (number of individuals)

6.- Relative abundance

7.- Specific composition

8.- Geographical coordinates

9.- Grids with presence

10.- Presence (propagule pressure indicator)

All these activities take place on or close to the coasts and serve to obtain greater knowledge of the marine environment, as well as their possible conservation or exploitation of marine resources, preventing in some cases the over-exploitation of the environment or the exhaustion of the resources and opting for their conservation as a natural heritage.

3.3 Monitoring Campaigns

In the previous section, we have exclusively indicated the needs of monitoring the submarine environment, not only to assess the environmental status of the coastal subtidal zone, but also to correctly assess the environmental impact of works and other human activities carried out in these spaces.

The methodology for carrying out these works must be as efficient as possible, since the immersion time is limited, the work environment requires a large infrastructure and therefore the cost is up to ten times higher than the work of similar type made on land or in laboratories. This is due to the need for boats, the number of divers needed to carry out the work, the cost of diving equipment and research material, and of course all the necessary and essential material that guarantees the safety of the people They work in the marine environment, be it these patterns, sailors, scientists and scientific divers.

In monitoring many techniques are used, depending on the work to be developed, among these techniques are the visual census, transept, quadrantal, installation of biological or archaeological work field, in addition all biological data have to be accompanied by data corresponding to the biotope which forces the installation of measuring equipment (multiparameter probe, current meter, photometer, etc.), collection of in-situ biomass, sediment collection, and the taking of photographic or video images, which leave evidence of the studies carried out [35].

The work protocols well developed and followed to the letter are a guarantee of effectiveness of the resources used. The protocols are based on safety, the responsibility of the participants in the dives, the prior and detailed knowledge of the equipment to be used and the emergency systems; Following its protocols there will be a greater guarantee that everything goes well, with high levels of security for the people who make up the work team [17].

We will make a synthesis of the different manuals that have been prepared by experts in the field with many years of marine research, however the manual NOAA frequently insists on the need to adapt the immersion protocols to the type of work and the physical and environmental characteristics of the space to be studied.

3.3.1 Scientific Coordinator

The scientific director is responsible for the research project, is responsible for the formulation of hypotheses, experimental design, and is the main point of contact for all scientific aspects of the program, including maintenance, use, calibration and scientific equipment.

Economic responsible for the project or study to be carried out.

Select the place of the diving campaign and the specific diving points, number of divers and their training profiles.

Working with the head of security (Divemaster), the scientific director will be responsible for the training of divers in specific scientific tasks (recognition of species, ecosystem assessment etc).

Monitor and control the number of samples to be collected, their conservation methods and the capacity of the accumulation of samples or data after a dive and analyze the immersion afterwards.

3.3.2 Chief of Security

As already indicated, we work in a difficult and complex environment that requires avoiding recklessness or carelessness. Many of these imprudences are committed with the purpose of cheapening or finishing work, sometimes the diver himself does not realize that error, hence the importance that the trips to the sea must be controlled by a security chief.

He is responsible for the safe and efficient conduct of all diving operations and divers. You must have the superior diving certification and have completed the training program. When there is no chief of Security, diving will not take place [25]. It will ensure that all divers have the appropriate qualifications for the requirements of the dive and will assign the work tasks to each according to them.

You must ensure that all divers are well informed about the mission and objectives of the operation. When special tools or techniques are required, you should make sure the divers know about them and their applications.

Responsibilities of the Chief of Security:

1. The overall responsibility of the diving operation

2. The safe execution of the entire dive

3. The elaboration of a basic plan of operation, including the management of evacuation plans in case of accident

4. Be the link with other organizations

5. The proper maintenance inspection of the equipment

6. Repair and stowage of equipment

7. The selection, evaluation and briefing of divers and other support personnel

8. Monitoring the progress of the operation and updating the necessary requirements

9. Maintenance of the diving record

10. Decompression monitoring (when necessary

11. The coordination of the ship's operations when the divers are in the water

12. The decision to suspend the dives, after consultation with the project coordinator.

3.3.3 Divers

Although the chief of security is responsible for the general operation of diving, the diver is responsible:

1. Keep yourself in proper physical condition

2. Check the personal equipment before the dive

3. Know the purpose and procedures to be followed in the dive

4. Follow the instructions of the security chief during the dive

5. Know where the emergency teams are.

6. Know the security and evacuation plans.

It is also responsible for refusing to dive when:

1. Conditions are insecure

2. Not in good physical or mental condition

3. Security rules are violated during the dive

4. Assigned tasks outside the limits of their training

3.3.4 Support to Divers and other Staff

In diving operations the number and types of assistance to divers depends on the size of the operation and the type of diving equipment used, vessel, point of access to the sea, reception, transport and conservation of collected samples, equipment storage , etc.

Ideally, the surface support personnel who work directly with the divers should also be qualified divers. The use of unqualified personnel who do not understand the techniques or terminology can cause confusion and can be dangerous.

Unqualified persons can collaborate when necessary, but only after they have demonstrated that they understand the procedures in the judgment of the chief of security.

In addition, in each scientific diving outing, it will be necessary to have:

• Oxygen and first aid kit

• Slates, pencils and aladores

• International flag of Alpha signs, indicating the presence of Divers in the water.

• Regulators, glasses, fins and spare batteries, as well as tools for small repairs.

• Drinking water and possibility for divers to enter dives eat something with glucose (cookies, chocolates, soft drinks orhot drink like tea or coffee).

• Location communication system, although currently the mobile phone provides a high level of communication and location, it is necessary to have a UHF radio that allows, if it was necessary to send distress calls to channel 16. A radio of this type has to be in the boat, but it's function of the Chief of security check its proper functioning. Also in It is essential to have a GPS device.

3.3.5 Air Supply

This is a very important factor to take into account, particularly when the monitoring campaigns are carried out outside the normal working base lasting several days, it is necessary to have a reliable supply of compressed air to recharge the bottles in good conditions of use. The head of security is responsible for this aspect but can delegate this function to any other member of the campaign suitably qualified, to know the requirements of air supply must be taken into account:

• Diving equipment and bottles

• Depth of the dives

• Time of permanence in the fund

• Number of dives to be made

• Consumption spreadsheet

3.3.6 Contingency Plan

It is about having a protocol for assistance in case of accident and emergency information, this must be prepared in advance and can serve for the entire sampling campaign, unless dives are carried out in singular sites that require an individualized treatment, in summary they will consider The following items:

• Name of the place and GPS situation of the campaign

• Nearest municipality (GPS situation) latitude and longitude of city

• Emergency telephones: marine rescue, police, hospital, ambulance, Civil Guard, radio numbers of the UHF channels

- Insurance company of each diver and policy number
- Contact procedures for the evacuation team
- Decompression chamber and nearest hospital
- Inform the Civil Guard prior to the campaign of the situation and number of divers, particularly if the work group is large
- Evacuation route of the different dive sites

3.3.7 Programming of Operational Tasks in all Phases

In a campaign where a series of immersion days are carried out in each dive or at least at the beginning of the day, it is necessary to consider a set of activities that will favor the achievement of the objectives.

3.3.8 Analysis of the Data of the Immersion Point

Conditions on the surface, as well as the state of the sea, air temperature, wind and cold. All this information is given by different meteorological services such as the Spanish Meteorological Agency, the European Prediction Agency, Ports of the State or Windgurú.

Underwater conditions, including:

- The expected temperature of the water and its variation in depth
- Depth of the dive and type of bottom, the information is in the nautical charts
- Tides and currents the tide information by the tide calendar and the information of the local currents by previous knowledge or personalized information
- Visibility, according to the wave situation or the time of year
- Degree of contamination, if it is a spill area or outlet of emissaries
- Potential risks, particularly with fish, lost nets, abandoned aquaculture cages, navigation path, dinghy sailing, jet skis, etc

3.3.9 Final preparation and security check

1. Review of the dive plan, its effects and security measures

2. Summary of the diving activities and their sequence

3. Checklist of site features and security measures

4. Review of divers' qualifications and environmental conditions

5. Ship permissions and diving capacity

6. Transfer to the dive site

7. Assembly and operation of the equipment

8. Pre-briefing.

- The objectives and supervision of the diving operation
- Conditions in the area of operations
- Diving techniques and equipment used
- Functions specific to each diver
- Hazard forecast
- Normal security measures
- Special considerations

3.4 Submarine Sampling Techniques for the Biological Monitoring of Submerged Ecosystems

The requirements of monitoring the submerged ecosystems raised by the European directives and exposed in a previous section can be summarized in the need to measure:

Biocenosis data:

- Abundance (in terms of biomass, coverage, density of species, number of species and number of individuals).
- Relative abundance
- Specific composition
- Grids with presence
- Presence (propagule pressure indicator)
- Visual fish censuses
- Possible pollution indicators

Biotope data:

- Geographical coordinates
- Typology of funds
- Sediments

We can combine all these measures in terms of ecological density.

- Absolute density is simply the number of organisms (or of a single organism) that occupy a unit of area or volume.
- The relative density is the density of a population in relation to that of another or several population without estimating how many individuals there are of each species.

• The relative density is easier and cheaper to determine than the absolute density. However, it is necessary for most ecological research to include absolute density.

• Number of sample plots sufficient to have reproducible data. In general, the more repetitions the more accurate the estimation of the composition of the community. This is an important issue, since it ultimately forces the researcher to make a cost / benefit decision. The "benefit.ºf increasing the number of samples, that is, increasing the number of repetitions, transepts, etc ... looking for an increase in the precision of the estimates of composition and abundance and density of species.

• It is also absolutely necessary to be able to determine in each case the unit of minimum sampling area. A simple but reliable method of determining when a community has been adequately analyzed is the plotting of a species accumulation curve.

• It is essential to work with a previous statistical design that facilitates the analysis of the results

• The statistical comparison of two or more treatments is reinforced by an equal sample size. The observation procedures will be as identical as possible to reduce the number of uncontrolled variables

• The same sampling method should be used and sampling should be done at the same swimming speed, trying to take the same time.

• Sampling must be done by the same people

• You must be at the same depth in the different locations

• The samplings must be done at the same time of day and in similar conditions of weather and tide

• The samplings in each location should be carried out in the shortest possible period and the two locations should be sampled

3.4.1 Transept

The linear transept is a way of dimensioning a work surface since the linear measurement incorporates distances to right and left that will give us a surface, which as we said before should be the same in all locations to facilitate statistical comparison. A length will vary according to the depth, the lower the depth of the sampling, to allow the divers to make their measurements without exhausting the air [10].

It can be parallel or transversal to the coast, everything will depend on the study that we wish to carry out. This work technique is a very economical method, with it we can obtain the relative abundance of different species, diversity and the typification of both hard substrate and sand that exists in the middle. One has the error of thinking that the transept only serves to obtain data in the horizontal plane of the surface and not in the relief.

There are many jobs that are usually done with this technique: visual censuses, cartography and inclination of the slope. It is one of the non-destructive techniques so it is one of the most used.

The transept simply requires a tape measure, as already indicated above, it must have a length of 20 to 50 meters, and the components of said tape, like the tape itself, must be made of a plastic material, which It will prevent its corrosion when we work with it at sea. In the same way, it will be easy to extend in the background and to collect once the immersion is finished; It is also usual to use a stick of 2 meters in length that moves over the transept leaving each side 1 meter away from the transept, this technique is used to count organisms (algae, macroinvertebrates, etc) [20].

Once it is fully extended, we will obtain what is known as Depth Inclination Orientation (PIO). The depth will be obtained every x meters and will depend on the work and what we want to obtain. It is usually taken at the beginning, every 10 meters and at the end of the transept; but if we use it to determine changes in vegetation cover it will be interesting to take the previous data, just where that change occurs. The inclination can be obtained in two different ways: the first one will be (in situ), in the place: a semi-circular rule is placed on a board and a thin end with a cross section is placed right in the center of the semi-circle. lead as a pendulum, once deposited this on the bottom will give us the degree of inclination that has the slope; the second is done in the laboratory; for this we will represent in a graph with a scale that we choose depth versus distance. As we have been obtaining the depth throughout the transept, we will only have to represent it in the graph and with the help of a semicircular rule we will know exactly the inclination of our background. Also with the help of a compass we can know the real distance studied. This is done by placing said compass on the axis of the depth, exactly at the lowest depth; we will extend it in our scale every 10 meters and we will cut over the line of our represented graph, thus we obtain the distance in actual length traveled [36].

Another data that we can contribute to our work is the roughness of the seabed, this is usually done by a chain, which will extend into the seabed. The values can range from 0 to 5, where 0 is a smooth background (non-existent roughness) and 5, an abrupt background (maximum roughness).

In bionomic cartography the following data should be taken: depth, inclination, orientation and roughness. We will also place the scale with which we have represented the graph, drawing in it the cartography and the type of algae that we have found along the transept, indicating where the change of type of coverage has occurred, so we can represent with almost complete accuracy the plant cover of the seabed. To obtain the geological cartography the exact same thing will be done, only instead of including the plant cover of the seabed, we will add the type of marine substrate: large rock, small rock, sand, lava flow, paleo-cliff, sedimentary rock, sedimentary bar or gravel (pebble) etc.

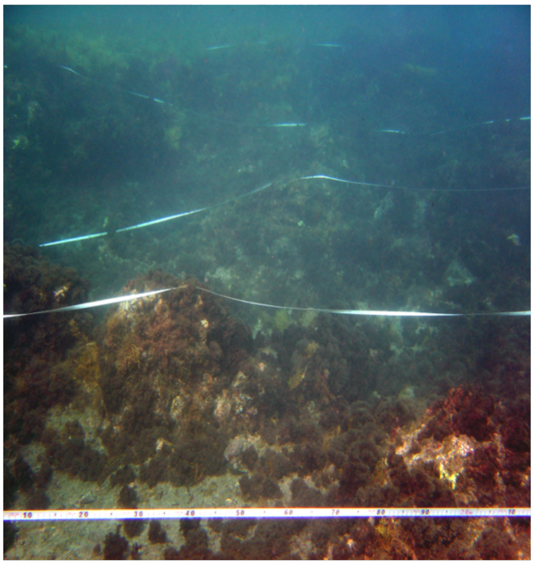

Figura 3.2: Scientific Diver: Transept

3.4.2 Visual Censuses

This sampling technique is one of the most used, it is a non-destructive or invasive technique, there are several methods of work:

The first is known as the band transept method, it consists of going over a transept pointing the fish that are being observed, this of course must always be done by at least two divers in order to later compare the data.

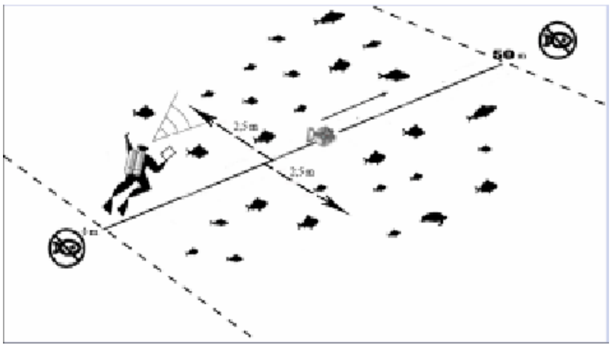

Figura 3.3: Buceador Científico: use Belt Transect Method (English et al., 1997).

For this, the number of individuals and the size of the fish will be taken as important data, the fish census will be carried out on the benthic and demersal, never on the pelagic ones, since this would alter the sampling, it is what is called "meter"noise .ªnd consists of altering the data in our spreadsheet, something because the pelagic move through the water column, from one place to another, not staying a long time in one place. Only contrary cases have been described in the diving areas where fish are fed by the divers themselves [38].

The second as a stationary census, the divers are placed back to back at a fixed point for a certain time, this can be done along the transept, randomly or having determined in advance [18].

Although this technique has certain disadvantages, such as: depth, temperature, water transparency, currents and limited time in the bottom, all this can affect the diving operations [11].

The errors in the visual census are:

The tendency to not sample small cryptic species or nocturnal habits, error in the counting, identification and registration, attraction and aversion of some species to divers, differences in territoriality and range of habitat.

These errors are inherent in the technique and, as they are done in all situations, comparisons between different spaces are considered valid.

Figura 3.4: Scientific Diver: Visual censuses

3.4.3 Quadrantal

This term is used to refer to the square sampling unit, within which the quantity of organisms is measured, these measurements are given in % coverage of the species, although it is important to indicate that it only serves to determine the benthic species that they are fixed to the substrate, with this system we obtain densities, abundance, diversity and size of the substrate or colony in the case of corals or sponges.

Although the square meter is usually used as a reference, in scientific diving techniques we work with a more operative quadrantal, this is usually 50 by 50, which in turn is divided into 25 squares of 10x10 cm, which means that each square occupies 4 % of the surface of the square. Counting the number of squares that a certain species occupies will have its coverage percentage. If what is done is a count of individuals of a certain species its density will be taken and if the individuals of all the present species are counted, the relative density values are obtained and the biodiversity indexes can be calculated by elevating the data obtained to the subway square [22].

The work system is to randomly pull the quadrantal on the bottom or at distances measured on both sides of the transept, the divers who perform this work, must be away from each other, this prevents divers doing the work are influenced each other , and thus be able to guarantee that the information obtained is as truthful as possible [14].

The density is the total of the different species that are present in the given area, this is given in square meters, the Shannon-Waver index combines the number of species and relative abundance, giving the existing density.

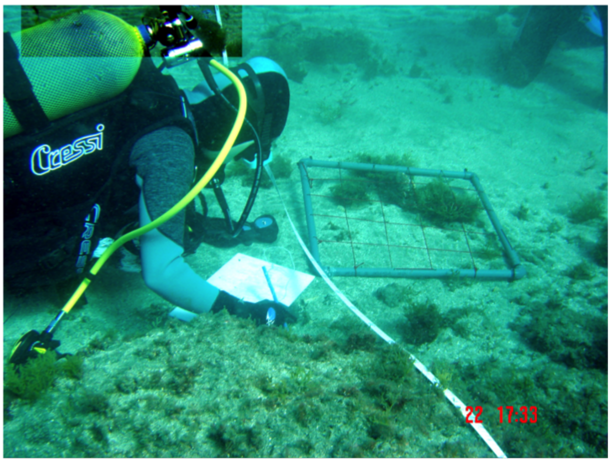

Figura 3.5: Scientific Diver: Quadrantal

3.4.4 Work Field

These fields of work are linked to both underwater archeology and biology or biological archeology, underwater archeology is undoubtedly the youngest discipline in the world of archeology, this is linked to the birth and subsequent development of autonomous diving, tasks of underwater research follow the same scientific rigor as any of the scientific investigations carried out in laboratories [40].

It consists of the delimitation of a surface, normally a square, subdivided in turn into several squares on which to work, it is a way of maintaining a unit of fixed surface that allows the statistical comparison between spaces. Also the work field if left installed on the background will allow the study of temporal variations, this system of work is known in archeology as archaeological excavation.

The use and assembly of a work field is a method widely used in underwater archeology but it is also used by marine biology. Its assembly is not expensive and is usually used when we have to work in a specific area for several consecutive days.

This procedure delimits us a specific area on which to work, which is good if we are talking about great depths, since we do not have to travel great distances collecting samples by having them concentrated in a limited area.

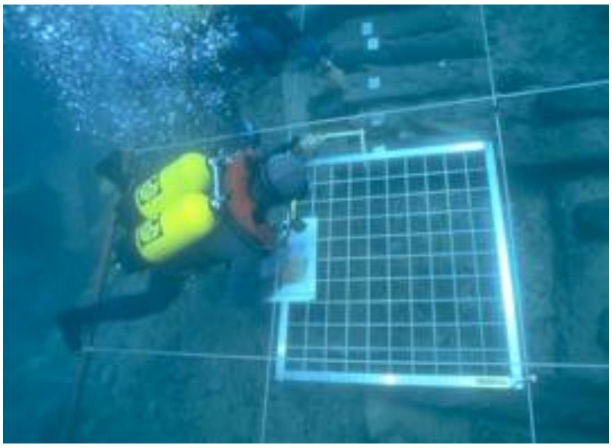

Figura 3.6: Scientific Diver: Work fild

With the help of the compass or a square and a measuring tape we will place the different stakes, we will help with a hammer and a meter to know the distance between stakes, we will place the reel with great care not to raise the bottom, inside the work field in the assembly we will do it with care, and entering only a diver to fix the central stakes [4].

3.4.5 Collection of Biomass

For the collection of biomass, for example, algae, we will use destructive sampling techniques, since these should normally be transported to the laboratory for identification, as it is done with the majority of invertebrates.

The techniques used for this are mainly two:

- The collection with hammer, chisel and bags that are hermetic.
- Use of a vacuum cleaner (chupona) with a collection mesh.

Biomass can be measured per unit volume or area, per trophic level or in an ecosystem. We can make an approximate estimate of the algae biomass (wet) expressed in g / m2 if it collects all the algae within a quadrant of 0.25 m2. For the determination of the biomass it is necessary to take the algae to the laboratory and dry them in a stove at 60º between 24 and 48 hours approximately [3].

For the collection of samples of biomass with chisel and hammer, select the work area, remove the macro algae by hand and put them in a bag, empty the air from the vest while a diver hits the rock with the hammer and the chisel, another introduces in the bag the remains that are detached, once finished the work closes the bag hermetically, the bags must go previously numbered and referenced.

Sampling with vacuum cleaner or chupona, the mesh is placed well on the upper part being well secured, the vest is emptied to be firmly in the bottom, the work area is marked to know the total surface to be vacuumed, to open the bottle very slowly of diving, make sure we have collected all the biomass just before closing the bottle, invert the tube of the sucker, remove the mesh from the tube and seal it well, place the mesh in the bag that we have numbered.

Important if the pacifier or vacuum cleaner is very large and heavy, remove the fins, ballast well in the bottom, separate the legs to avoid being absorbed by the vacuum cleaner, it is also recommended to use a hood when working with very large vacuum cleaners.

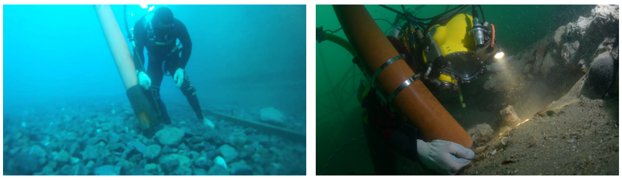

Figura 3.7: Scientific Diver: No fins and hood.

This technique requires that the aspirated surface is always the same and that the aspiration time is the same to have statistically comparative results. This technique also allows the collection of organisms that are located on the phanerogams or seagrass.

3.4.6 Collection of Sediments

The data on the sedimentation rates are especially important in fluvial environment, the population that constitutes the bottom load (bedload) are formed by the larger clasts, generally superior to 0.060 mm), these are transported by traction, while the of less size they are transported by suspension and settle.

he capacity of a water flow to transport sediment over time is determined by two main factors: magnitude and frequency [32].

Example of how to collect sediment samples:

• Take sediment with 60 cm syringe, cut the base, place the syringe as vertical as possible on the sediment, as we bury the syringe we remove the plunger, this operation must be done very slowly, once the plunger is on top of the everything, we will tilt the syringe a little, we will remove with great care and we will place the lid, we will press the plunger with the lid on.

• Sediment collection with Vinyl Polychloride (PVC) tube, place the tube as vertical as possible on the sediment, bury the tube in the sediment with the help of a small hammer, let the tube protrude about 5 cm from the bottom , we will place the top cover with the help of the hammer, once this operation is done we will tilt the tube slowly and place the 2nd cover.

• It is important that in the extraction of sediment with the tube mark the cover 1 and the cover 2 to know well the direction of entrance of the tube of PVC, since this extraction system is usually used to know the granulometry of the layered background, as happens with the extraction of sediment with the syringe.

• If we do not care about the granulometry by layers, the sediment can be collected with a shovel and a plastic bag or container.

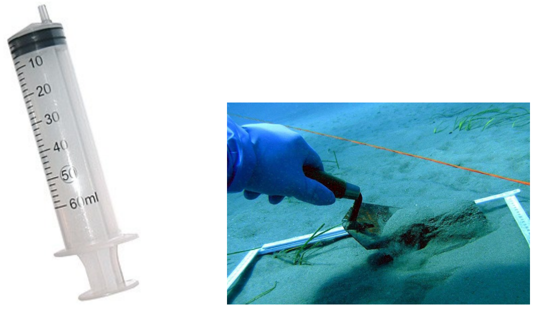

Figura 3.8: Scientific Diver: Work field.

3.4.7 Photography

Photography is a very important tool in scientific diving, it allows us to have testimony of the work done, it also helps us to identify the species, determine the biomass that exists. The use of this technique has become popular in recent years, both the photography and the underwater video, are methods used in scientific campaigns of deep benthos [13].

We can estimate the abundance of algae with a photo camera, a 28-mm lens and a frame to portray closely. Project the slides obtained in color and 35 mm on an 8 x 11 sheet of paper with points located at random. The number of points corresponding to each component of algae, for example: cespitose algae, calcareous, encrusting, microalgae and macroalga, these were added and expressed as % of the total algae cover.

Figura 3.9: Scientific Diver: Photographic grid and Stereoscopic camera https://www.pinterest.es.

Since photography has a dimensional vision, they can not be used to estimate the spatial relief. But the stereoscopic cameras or camera (3D) if it throws information on the relief, this system is more complex and requires sophisticated analysis systems.

These cameras try to imitate the behavior of the human eye, using two objectives at the same time, or using two separate cameras strategically.

To be able to make acceptable photographs and without much movement, we usually use a rigid and heavy structure that rests on the surface we want to photograph, usually has several flash on top with automatic trigger system, or synchronized between different flash, shooting one shoots the others without firing them.

But it also has its limitations when we design monitoring programs and select a sampling location, such as: When sea conditions do not allow it due to turbidity, strong current that prevents us from taking a good photo, long distance photograph, Resolution of the water that is not clear enough to identify the organism.

3.4.8 Video

Video recording has certain advantages over photography in ecological monitoring. Although video filming is ideal, if we want to quickly photograph a large area, we will have problems when it comes to comparative and quantitative analysis.

The video can provide us with qualitative information about ecosystem conditions, these can be imported into a graphic analysis program, although these are very expensive tools, they can speed up data collection.

The video provides us with a vision of the ecosystem, this, unlike photography, is useful to carry out visual censuses, if we make a correct use of the video camera.

Another function of the video is that it serves as a witness for those people who can not submerge, leaving clear testimony of the work done and then be able to teach everything seen at sea.

Today both cameras and video cameras are installed in Remote Operated Vehícle (ROV) and submarine drones, the latter travel the oceans capturing images and storing them in their database. These images once the drone is recovered will be analyzed by the scientific team.

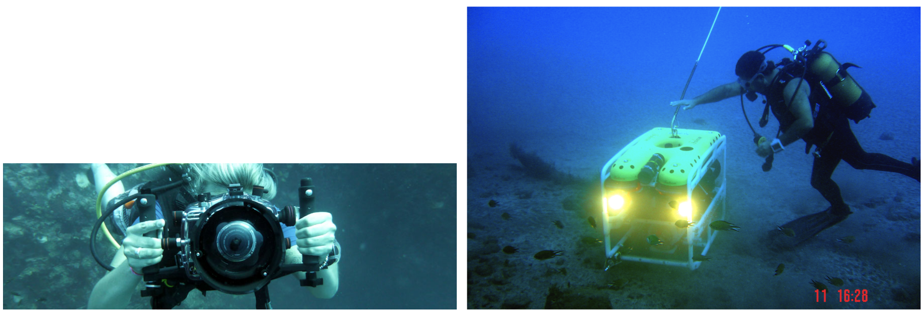

Figura 3.10: Scientific Diver: Submarine video and ROV.

3.5 Training of Scientific Divers

Among the most important international organizations in the world of scientific diving, we find: AAUS, NOAA, CMAS, UNESCO, CAUS, each of these organizations have aimed at their protocols, ensure the safety of scientific divers and scientific diving, as a working tool in marine research and sweet aquaculture, teaching scientific diving courses archeology and biology [29].

These international organizations publish manuals on scientific diving, they give courses for training in scientific diving, the courses are aimed at the scientific community in general, not being able to participate in these courses those who do not have university training or a working relationship with public or private research groups [19].

The courses train the scientific diver in the sampling techniques and the necessary knowledge for the development of work, research, safety in diving, organization of work teams, development of evacuation routes before a possible emergency, training and conservation of the medium in which it moves. To this end, it has created an ethical code, this code of ethics serves for the conservation of the marine environment and to avoid the exploitation or exploitation of marine resources [21].

There are other diving organizations such as: CMAS International Organization (PROTEC), International Association of Nitrox and Technical Divers (IANTD), Professional Association of Diving Instructors (PADI), America Certification Underwater Candian (ACUC), National Association of Underwater Instructors (NAUI), International Diving Educators Association (IDEA), Scuba Schools International (SSI), etc, with a lucrative spirit, but with the same common interest, the safety of people who are dedicated to diving, be they professional, scientific or sports-recreational, their intention is always to make known the environment in which they move and the protection of the marine ecosystem.

In recent years the universities have implemented these courses in their teaching plans, these are demanded mainly by the need to prepare future professionals in underwater research. In the report made by the National Agency for the Evaluation of Quality and Accreditation (ANECA), on the races in "Marine Sciences" they recommend carrying out a greater number of practices and trips to the sea, as a fundamental basis for the formation of future "Graduates in Marine Sciences" [2].

This demand has also served so that the personnel of the different universities acquire a training according to the needs of the work, thus obtaining a greater specialization and professional qualification.

This demand has also served so that the personnel of the different universities acquire a training according to the needs of the work, thus obtaining a greater specialization and professional qualification.

Some of the Spanish Universities have included scientific diving in their teaching programs, providing greater knowledge of the marine environment. This teaching module is thus incorporated into the lives of future professionals, being responsible for research projects in the marine environment. The courses are taught today in the careers of Marine Sciences, Archeology, Biology, etc. (Annex A Table A1).

The preparation and training more and more specialized in the techniques of underwater work tries to avoid underwater accidents, due to misfortunes many of these accidents continue to occur in the sports-recreational and professional world [23].

3.5.1 Content of Scientific Diving Courses

The contents in the scientific diving courses can be varied, these will always depend on the organizations, centers, institutes or universities that impart it, in a generic way these courses usually have as main subject: Biology, physics, physiopathology, ecology, archeology, tables Decompression, sampling techniques, organization in diving and as secondary materials: Instrumentation, work materials, safety in diving, legislation, organization at work, statistics, first aid, rescue, oxygenation, nautical knowledge, meteorology, etc.

Students enrolled in this type of course come from the university world with different careers, which facilitates the work of technical education, within the standards of CMAS is required to be able to take courses of advanced scientific divers that the person has a university education, since these courses are aimed at the complementary university training [8].

In general, these standards in terms of security are:

- Safety procedures.
- The responsibility of the team's dives.
- Employment and team procedure.
- Knowledge of the physics and physiology of diving.
- Emergency procedures

The standards are necessary for the safety of the diver, acquiring knowledge about the dangers in diving and what we should not do, if we respect the rules of safety and prudence in diving, nothing should happen, the good divers are not those that consume less and need less leads to submerge, if not those that at all times know in the environment in which they move, comply with safety standards and follow current legislation.

In addition to security, the courses have as a second part a thematic content according to their scientific and / or technical training objective:

- Animal Management
- Archeology
- Common biota
- Identification of organism
- Behavior
- Ecology

Knowledge about specific environments of special conditions such as: Oceanic diving, ice and Polar diving, zero visibility, diving in polluted water, aquariums, night, Kelp, caves etc.

The courses that are taught for this purpose speed up learning, it being very necessary apart from advisable to carry out these courses, the courses are aimed at all the people who start their path in the world of underwater research.

In order for a student to complete these courses, they must have a previous training in diving and behavior in the marine environment. In general, they are required to have a certification of having taken a first level diving course, Spanish legislation requires a current medical certificate and dive insurance and civil liability.

3.5.1.1 Biology

Botany:

Levels of organization of marine plants, ecology and distribution, morphological diversity, reproduction, biological cycle, systematics.

Marine Zoology:

Levels of organization, metazoans, pseudocelomados, arthropods, quetognatos, molluscs, fish, etc.

3.5.1.2 Ecology

Nature of ecology, environmental factors, population ecology, functional ecology, introduction to the theory of communities and systems, dynamics of benthic populations and general coastal systems, use and exploitation.

3.5.1.3 Physics

Law of Dalton, Henry, Amagar, Haldane, Boyle and Mariotte, Charles and Gay Lussac, principle of Archimedes, fluid, weight, density, temperature, law of Fick, humidity, light and sound.

Pressure: Atmospheric pressure, hydrostatic pressure, absolute pressure, partial pressure.

Gases: Air, oxygen, nitrogen, helium, CO2, argon, CO, etc.

3.5.1.4 Physiopathology

The human body: Skeletal muscle system, respiratory system, cardiovascular system, pulmonary system, nervous system.

Barotrauma: Ear, breasts, dental.

Intoxications: Nitrogen, oxygen, carbon monoxide, carbon dioxide and other gases.

Crushing, decompression sickness (Los Bends), air embolism, pulmonary over-expansion, narcosis.

3.5.1.5 Decompression tables

General knowledge of decompression tables, immersion calculation, consumption calculation, saturation tables in time and depth, altitude tables, Nitrox tables, Nitrox consumption calculations, simple dives, continuous dives, successive dives, dive computers (models and brands), rule of 90.

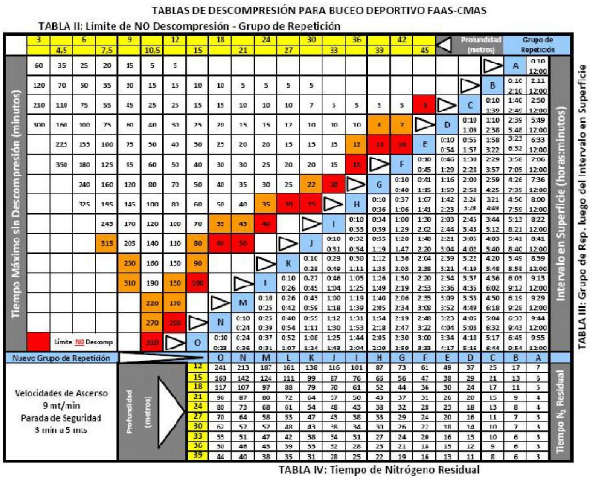

Figura 3.11: http://www.fotoseimagenes.net/tablas-de-descompresion CMAS.

3.5.1.6 Archeology

History of archeology, fundamental principles, cataloging, processing systems, collection and sampling, legislation [33].

3.5.1.7 Organization in diving

Organization of diving teams, project manager, head of security, planning of the dives, transport, meteorology, qualifications and insurance.

3.5.1.8 Instrumentation and work material

Probe, Global Positioning System (GPS), radiometer, multiparameter probe, niskin bottle, current meter, hydrostatic balloon, hammer and chisel, chupona, underwater hydraulic drill, underwater hydraulic hammer, metal detector, underwater torpedo, etc.

3.5.1.9 Safety in diving.

Organization of the contact agenda, maritime rescue, civil guard of the sea and Special Group of Underwater Activities (GEAS), Red Cross (CR), hyperbaric chamber, etc.

Safety buoys, guide line, safety distances, sound and acoustic signal equipment, flags, safety bottle, power line, safety equipment on board, oxygenation kit, first aid kit, telephone, marine transmitter, lifebuoy.

3.5.1.10 Legislation

Safety rules in diving, scientific diving decree, scientific diver code of conduct, international maritime law, international law of the sea, national and international submerged heritage legislation, legislation on protected species and special sensitivity, marine reserves, II Convention Collective of the Diver.

3.5.1.11 Organization at work

Information about the work area, preparation of the work material, information about the weather conditions, work to develop, interpretation of topographic maps and navigation charts.

3.5.1.12 First aid and rescue

Surface rescue, bottom rescue, diver's tow, diver hoist, search and recovery systems, orientation, compass management, cardiac massage, fractures, hemorrhages, bandages, burns, bruises in general, treatments to follow and cures , identification of early or late death.

Figura 3.12: http://formacion.cruzvermella.org/Auxilios en el Buceo.

3.5.1.13 Oxygenation

Asphyxia, oxygenation equipment and its parts, respiration frequencies, identification of asphyxia, drowned blue and white drowning, such as placing a guedel cannula or may tube, types of masks, ambur and reservoir bags.

Figura 3.13: http://clubpastinaca.blogspot.com.es kit de Oxigenación.

3.5.2 Scientific diving qualification

The qualifications and scientific diver's license issued by the different diving organizations do not usually have validity to work as a professional or scientific diver in Spain, but if to demonstrate their scientific qualification, other countries do recognize the qualifications of a scientific diver, being able to be hired professionally. and develop their activity without any problem, opting for an employment contract as a scientific diver [26].

However, the Spanish Institute of Oceanography (IEO) publishes in 2017 a place for scientific and laboratory diving techniques for the ecological assessment of marine angiosperm grasslands, IEO Murcia.

In the United States, the scientific diver has to register in the AAUS, in this way would obtain a permit, being registered in the database of the organization as a scientific diver.

CMAS is one of the organizations with more international recognition, this is because more than 144 federations are part of it, and because of the recognition it makes in the world of diving in general and in particular in scientific diving , this has led him to obtain the recognition of the UNESCO, together they have elaborated the code of ethical and moral conduct of the scientific diver, as well as the recognition of the titles and programs of the scientific diver.

As we have already mentioned, 144 federations from different countries form part of CMAS CIENTIFICA, constituted only by scientists and researchers, these federations every 4 years elect their president and the board of directors. They hold regular congresses, at the congresses the work and techniques used in scientific diving are exposed, they also constitute work commissions that serve to improve scientific diving and quality standards.

The UNESCO through CMAS, has recognized the different degrees that this organization grants to students who meet the teaching standards, with these titles you can work at a scientific professional level in different countries of the European Union.

Within the certifications CMAS there are four titles, according to the diving training that the student has, he / she will be able to access some of the following titles:

- scientific diver.
- Advanced scientific diver.
- Scientific diving instructor.
- Instructor of scientific diving instructors, the latter is the highest degree to which a scientific diver can aspire, since he is responsible for training future instructors in scientific diving.

At present, ÇMAS CIENTIFICA"has recognized 5 official centers, these centers teach courses every year regularly. The centers can be completely autonomous or be within research centers or universities.

- CMAS Scientific Diving Center UNIVALI is located at the Submarine Mergulho Laboratory at the Universidade do Vale do Itajaí UNIVALI in Itajaí SC, Brazil.
- CMAS Freiberg is part of the Technische Universit at Bergakademie Freiberg (TUBAF). It is supported by the Geoscience Department in the Faculty of Geoscience, Geoengineering and Mining Institute of Geology, Prof. Merkel. Freiber Germany Provides services to all students of the University (TUBAF) and to external students. Website: http://tu-freiberg.de/sdc
- CMAS Scientific Diving Center CSC (GER / S01) WiTUS is associated with the diving club TC Uni Stuttgart Manatees (www.tc-manatees.de) of the VDST. Faculty of Energy-, Process- and Bio-Engineering (www.vdst.de).
- CMAS Scientific Diving Center (ESPS00) Las Palmas de Gran Canaria, Spain. Within the Department of Biology. Faculty of Sciences of the Sea. University of Las Palmas de Gran Canaria. Las Palmas, Spain.
- CMAS Scientific Diving Center at the University of Alexandria, Egypt.

Figura 3.14: Certifications CMAS.

As we have said before, there are many international and national organizations that offer training courses, but they are not the only ones that nowadays develop this type of courses in their classrooms, this practice is extended both National Universities and International Universities Annex table A.1 and table A.2, these teach scientific diving courses within their teaching programs either as a subject of the race or as a complement to the career.

4 Discussion

Marine scientific research was already considered as a branch of the law of the sea during the first session of the Third United Nations Conference on the Law of the Sea held in Caracas from July 20 to August 29, 1972 where it was collected The need to delve deeper into this issue, even some authors have come to consider that marine scientific research is a technical aspect and relatively marginal in appearance, has become one of the most delicate problems in the formation of the new law of the sea [15].

The 1982 United Nations Convention on the Law of the Sea establishes the legal framework, the third part of which is entirely devoted to the subject of marine scientific research [1].

The legislation on scientific diving in Spain is recognized by the different existing laws, both nationally and regionally and has been debated between the convenience or not of applying to scientific diving the rules of professional diving or recreational diving. These have undergone various modifications since the safety standards for diving were published in November 1997, with a subsequent modification in the section on scientific diving in the year 2000 and now state legislation requires the training of sports diving to scientific researchers.

The Government of Canaria after receiving the powers on professional diving and sports-recreational develops its own decree, annulling the decree of MF of the year 2000 on scientific diving, with this new decree at the regional level decides that said underwater scientific activity It will be developed by professional divers, this led to a new debate on the subject of training and recognition on who can or can not develop underwater scientific activity. However, this regulation has not been applied and the Deputy Ministry of the Environment has requested its correction.

Currently, a document signed by scientific divers, doctors, professors, students, technicians and support personnel has been presented, requesting that the new regulation introduced on scientific diving in Spain be modified and approved. It is important to highlight that many of the Today they are dedicated to scientific diving are professional divers, they recognize that this activity can be exercised by divers who have a sports-recreational accreditation as long as they are scientists and move within the world of scientific diving, and do not use scientific diving as a profitable professional activity, since this tool must give support to the research activity, and that these scientists are hired for their knowledge about the environment in which they carry out their work, osse, as experts and not as scientific divers [41].

The need for trained scientific divers has increased markedly since the European Parliament establishes the need within the Community framework of action on the field of water policy, said directive in section 3 says: "Waters must reach a good ecological status and chemical, to protect human health, supply, natural ecosystems and biodiversity ", with this directive is intended to maintain the best quality of water both coastal and terrestrial including hydrographic waters [?].

The ecological state is defined as: The abundance of both aquatic and fish flora, nutrients, salinity, temperature and the presence of chemical pollutants; in terms of morphological characteristics, the amount of water, the flow, depth and structure of the river beds must be taken into account. This situation requires extensive underwater monitoring programs that require the training of personnel prepared for its implementation and this falls within the objectives of scientific diving.

In order to achieve these objectives, the European Union (EU) during the conference held in Malta on 5 and 6 October 2017 committed to take concrete actions to achieve healthier, cleaner and safer seas. One of the measures to follow is that the waters of the Member States reach a good environmental level by 2020, and for this purpose they will invest € 2 million, another € 2.85 million for prevention and preparation projects in the field of marine pollution, as well as € 2.5 million for the development and cross-border cooperation between the countries of the EU and neighboring countries [5].

Spain with its 5,849 km of coastline and as a member of the European Union can not ignore this directive. The decree establishes a series of quality parameters that can only be evaluated with scientific diving techniques [6].

To carry out the monitoring campaigns, teams or groups specialized in the techniques of monitoring, surveillance and control in underwater scientific activities are required. This team will be formed by a Scientific Coordinator: He will be responsible for the scientific campaign, Head of Security: Among its functions is the surveillance and control of the human team that performs the dives, divers: Qualified personnel hired to carry out the functions to be developed in said work, support: Material necessary for the development of said work and provide security to the personnel it is done [31].

The scientific activities developed at sea by scientific research teams must be previously directed and well defined, so the programs of the tasks to be performed are very important and these tasks must be agreed beforehand before boarding, although during the campaign can change the sampling system or agree other tasks due to sea conditions.

Whenever possible we will carry out a first assessment on the high seas, analyzing the data obtained, this first assessment will help us determine if the work is being carried correctly, once on the ground we are obliged to verify that all the data are correct.

To be able to develop underwater scientific work requires good control, management and knowledge in underwater sampling techniques, these techniques are used in multitudes of scientific work whether these technicians, final degree projects, final master projects, doctoral theses or scientific publications.

Within these standardized sampling techniques by different international and national diving organizations we find transepts, cuadrantales, visual censuses, as well as the use of filming media such as photography and video.

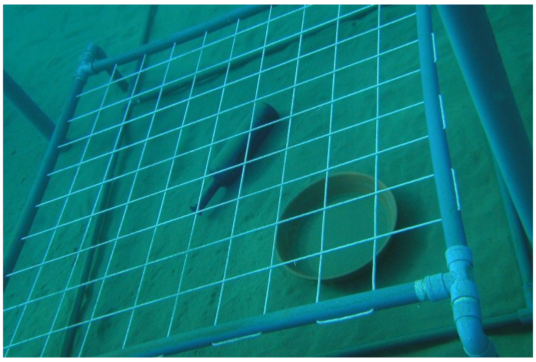

Figura 4.1: http://buceocientifico.com

The different international or national diving organizations, as well as the universities, marine research institutes and public bodies dedicated to research, be they aquatic or underwater, develop manuals and guides on the different techniques to be used in scientific diving.

These manuals or guides are used as a pedagogical tool in the different professional teachings that are taught about scientific diving, there is standardization in scientific sampling techniques.

A very important part of the development of the manuals, guides or courses of scientific diving is the safety of the people who develop their activity in this environment, all the organizations that are dedicated to this have elaborated safety standards and the ethical behavior of the diver scientific.

5 Conclusions

1.- Many of the works that are carried out in coastal management, whether these are monitoring, surveillance or research are developed with scientific diving techniques.

2.- In order to carry out these works with guarantees, qualified personnel are required in the different sampling techniques.

3.- The training of scientific divers is important and this is confirmed by the different international and national organizations.

4.- The requirements of these organizations guarantee the good practices and behavior of the divers, including the safety of the scientific divers who carry out these activities.

5.- The different legislations give legal coverage to the development of this activity, making it clear at all times that it is not a professional activity, but a tool that is used by professionals who are dedicated to marine and underwater research, developing their activity at sea.

6.- The member countries of the EC are obliged to comply with their directives, within the different directives is that of the control of their coastal waters, as well as maintaining a good environmental state of the marine environment.

7.- Scientific diving is mentioned as material and method in many of the scientific publications, the use of the different techniques described in the different manuals are recognized in international publications.

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Annex

A first annex

Tabla A.1: Universities, Superior Schools and Spanish Armada

National Estates Table			
ORGANIZATIONS	SCIENCE	BIOLOGY	ARCHEOLOGY
U. ALICANTE	X		
U. CADIZ	X		X
U. GRANADA	X		
U.I.B	X		
U. LAS PALMAS	X	X	
U. MURCIA	X		
U.P.C	X		
U. VALENCIA			X
U. ZARAGOZA	X		X
C.B.A	X		
E.S.CDA	X		
E.T.E. VIGO	X		

Tabla A.2: Country

Table Universities or International Higher Schools		
ORGANIZATIONS	COUNTRY	SCIENTIFIC DIVING
U.QUEENSLAND	AUSTRALIA	X
ADAS	AUSTRALIA	X
JETTYDIVE	AUSTRALIA	X
ABYSS	AUSTRALIA	X
U. SYDNEY	AUSTRALIA	X
U. TASMANIA	AUSTRALIA	X
OW-USS	AUSTRALIA	X
UNIVALI	BRAZIL	X
BMSC	CANADA	X
UACh	CHILE	X
UCSC	CHILE	X
CMAS	CUBA	X
SDU	DINAMARCA	X
UEES	ECUADOR	X
NORDIC MARITIME GROUP	FINLANDIA	X
SDC	GERMANY	X
TUBAF	GERMANY	X
U. DE PISSA	ITALIA	X
OW-USS	IRLANDA	X
U.GUADALAJARA	MEXICO	X
UNAM	MEXICO	X
I. SMITHSONIAN	PANAMA	X
FPAS-CMAS	PORTUGAL	X
URU	URUGUAY	X
U. WALLA WALLA	USA	X
ESF	USA	X
DIVE CENTRE MANLY	USA	X
U. ALASKA	USA	X
SCM. INSTITUTE	USA	X
UTD	USA	X
AACC	USA	X
ATM	USA	X
U. FLORIDA	USA	X
OW-USS	USA	X
UCSC	USA	X
U. OREGON STATE	USA	X
UCLA	USA	X
SDM	USA	X
U. MONASH	USA	X