

## **KEEPING TRACK OF SCIENTIFIC DIVES IN COUNTRIES WITH INCIPIENT DIVING PROGRAMMES: THE SCIDIVE RECORD FORMS**

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### **ABSTRACT**

Pre-dive checks and dive logs are fundamental documentation for any diving operation and must be incorporated as mandatory 'good operating practices' in scientific diving (SD) projects. Data included in dive logs may vary in detail, however, there is basic information to provide based on global standards. Differently to several developed countries in Europe, North America and Australasia, there are countries with incipient, sometimes non-regulated, SD programmes. In this article the importance of documentation in SD is highlighted and record forms are provided as templates, including versions both in English and Spanish. The Diving Supervisor (DS) is the designated person to fill the 'Daily SciDive Log' and 'SCUBA & surface-supplied LogSheet' (Table 1, 2 and 3, respectively), whilst every diver is responsible for filing their own 'SciDiver's Digital LogBook' (Table 4). General and specific considerations for all tables are described throughout the text. This effort was done to facilitate systematic data management and start developing the bases towards solid national/regional standards on scientific diving operations, particularly for those countries with incipient (scientific) diving programmes.

**Keywords:** scientific diving, dive logs, hyperbaric conditions, risk assessment, good operating practices.

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## INTRODUCTION

Scientific diving (SD) is one of the most insightful and cost-effective research tools used by researchers from a bewildering array of disciplines including benthic ecology, marine geology, maritime archaeology, and hyperbaric medicine [1,2,3,4]. Considered within the spectrum of occupational diving [5], SD falls into different regulations depending on the continent, region, or country of operation, for example: the 'Approved Code of Practice (ACOP) for Scientific and Archaeological Diving Projects' of the Health & Safety Executive, UK [6]; the 'Operation of Scientific Divers' of the German Commission for Scientific Diving [7]; the 'Polish Occupational Health and Safety Regulations for Underwater Works' [8,9]; the 'Occupational Diving Operations–Standard Operational Practice' [10]; and the 'Standards for Scientific Diving Manual' of the American Academy of Underwater Sciences, USA [11]. These regulations and standards separate consolidated SD programmes from those that are only just emerging.

Dive logging is a 'good operating practice' taught by diving agencies and organisations worldwide including the recreational, technical, commercial, and military domains (or 'sectors' *sensu* Wienke and O'Leary [12]). Each one of these demands different levels of logging; however, the general aim is quite similar; to keep a systematic record of the immersions conducted by each diver during diving operations. Additionally, the dive log is a necessary evidence for compliance of the requirements (prerequisites) for more advanced courses or specialties, independent of the diving domain [13,14]. Both pre-dive checklists and briefings cover a parallel function; however, these are designed as part of risk management endeavours to prevent incidents and accidents at work [15]. For SD operations, the design and implementation of the abovementioned should be of common practice in research conducted under hyperbaric conditions. Logged dives and related metadata are useful to detect trends and make quantitative analysis of historical data [16]; assess the risks associated to diving

operations [17]; use them as evidence in diving incidents/accidents investigations [18]; find information and visual resources effortlessly (personal observation); and contribute to the transparency and open data availability in scientific research [4].

Within the South American region, Peru is a clear example of a country with an incipient diving programme [19]. In countries where the overall occupational background of divers is underdeveloped and proper regulations are non-existent, only a minimum of control can be exerted from individual research units. A recent outlook of the operations executed by divers from the 'Universidad Científica del Sur' (CIENTIFICA Divers) emphasised the need of systematic data management for its inherent capability of keeping track of diving operations [19]. I hereby provide three different forms to be used in research operations relying on SD. Since the most common diving modes used for benthic studies differ in some attributes (Fig.1 (a) SCUBA [Self-Contained Underwater Breathing Apparatus], and (b) surface-supplied diving), each one requires a different log form. Forms are presented from general to specific. The first one, *Daily SciDive log* (Table 1), includes general information about the diving operation and it should be completed by the Diving Supervisor (DS) in charge during each day of fieldwork. A pre-dive briefing is here demanded. The second ones are both *SCUBA & Surface-supplied Logsheets* (Table 2 and 3, respectively) for cumulative dives undertaken during a single diving project. Effort is made to record times in order to integrate, synchronise or concatenate with other electronic devices such as cameras, data loggers and diving computers. Finally, I provide the *SciDiver's digital logbook* (Table 4), a very detailed form which should be completed by each scientific diver after every day of operation and shared with the DS for compilation. All forms and additional metadata are recommended to be kept in internal repositories or made freely available in online project repositories (e.g., GitHub, <https://github.com/>).

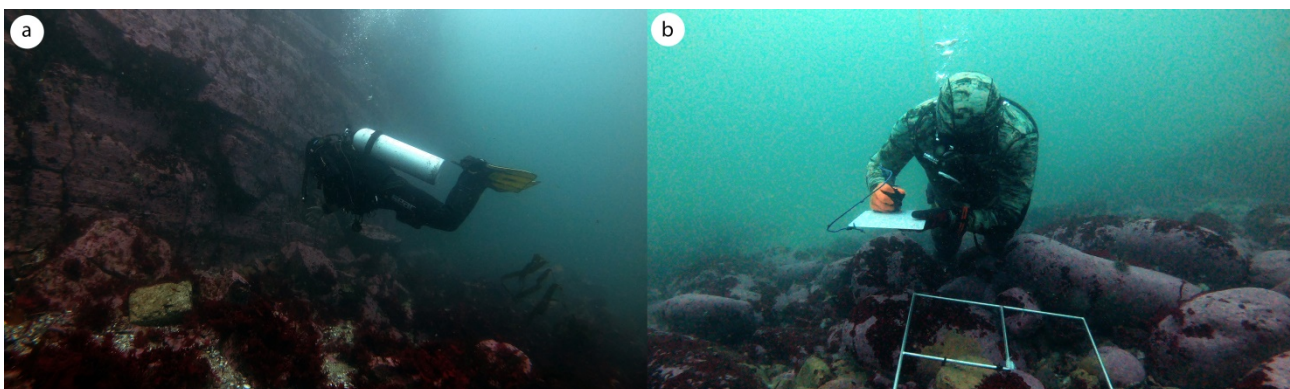


Fig.1 The two most common diving modes used by scientific divers (SD) in Peru: a) SCUBA, a SD in drysuit hovering and doing direct observations next to a vertical wall at 11 m depth; b) surface-supplied, SD annotating densities from the 625cm<sup>2</sup>-quadrat on an acrylic underwater slate at 8 m depth. Photo credits and locations: a) the author, Pucusana; b) Geanpierre Guzmán Urteaga, Pachacamac island.

## GENERAL CONSIDERATIONS FOR SciDIVE RECORD FORMS

There are some common considerations to bear in mind during form filling. Time: Date to be provided in YYYY/MM/DD format since this enables sorting in date order (oldest-to-newest logs, or *vice versa*). This is particularly functional for digital files and it is compatible with *ex situ* codifications of material such as photo/videoquadrats [20]. 'Left-surface' and 'emergence' times (to obtain 'total decompression time' *sensu* [21]), surface interval (SI) between dives should be annotated since this is one of the most important consideration for decompression planning (in the case of multi-level and multiple dives per day). It is highly recommended to set and synchronise all electronic equipment and logs to the GMT+00:00 time zone, by doing so, you can have an unequivocal and less erratic base-standard in case the SD team operates at different longitudes (hence, different time zones). Space: Location will be provided with common names of the site, sampling-station codes (in case of monitoring surveys or revisits), but most importantly, it should be georeferenced (geographic coordinates, indicating the 'zone and hemisphere' if the UTM system is used). Since *SciDive forms* are not limited to hyperbaric conditions at sea, fundamental information such as altitude (meters above sea level, m.a.s.l.) and surface barometric pressure (atm/bar) need to be registered since it is a mandatory input for obtaining the *theoretical depth* as part of the decompression planning for altitude diving (i.e., >300 masl) [3,22].

### DAILY SciDIVE LOG

Safety first. Emergency numbers (e.g., coastguards, hyperbaric centres, ambulances, firefighters) should be indicated and on hand to aid timely responses if any diving-related accident occurs. *Daily SciDive log numbers (No.)* should have unique values that are not repeated in the files of the SD unit. The responsible organisation and project name (including acronym) should be stated at the beginning since this will be part of

further codification in the following tables (forms). Distinction should be made between the project leader (or principal investigator, PI) and the diving supervisor (DS). The DS is responsible for conducting risks assessments, ensuring that scientific divers are fit to dive (i.e. have an approved medical examination); and are capable of conducting the planned underwater tasks (complying with the certifications and capacitation requirements); management, execution and supervision of diving operations and emergency procedures (if needed); registration, collection, and digitalisation of the forms. She/he can be assisted by a secondary DS. Both supervisors can also act as divers, however, the responsibilities should be re-arranged so that each participant only plays the role they are supposed to. All divers involved must sign, adding their maximum certification, agency code and provide valid insurance (e.g., Divers Alert Network, DAN). Diving modes (SCUBA surface-supplied, or CCR [Closed Circuit Rebreather]) and configuration (back-mount/sidemount and bailout; single cylinder or twinset) should be indicated.

It is recommended to briefly describe conditions at surface by annotating average ambient temperature, wind direction and speed (knots, kn), visibility, cloud formation, and other valuable environmental information. A daily pre-diving briefing should be undertaken ideally before embarking so all SD team members, assisting staff and crew are aware of the activities to be conducted. The decompression procedure should be indicated to know which one has been used to plan the dives. Since dive computers are the primary method for decompression planning in recreational and scientific diving [17,23], the brand, model, and the algorithm (e.g., RGBM, VPM) should be noted. Incidents and accidents must also be reported in this form. These include (but are not restricted to) the report of equipment failure (once identified, failing gear should be tagged correspondingly and not used until maintenance), report of decompression sickness (DCS; indicate the diver, circumstances, times and actions taken), report of other medical issues, report of other incidents (e.g., reasons for aborting a dive), and other emergencies.



Tab. 2

SCUBA SciDive Log Sheet.

SCUBA SciDive LogSheet																	
										[Daily SciDive Log no.]							
[Project name /Acronym_YYYYMMDD_#]				Pre-Dive				Post-Dive									
Diver name (add * if leader)	Dive team (#)	Surface Buoy	Cylinder size (L) and material (AL/SS)	Reserve: Pressure and size	%O <sub>2</sub> MOD	Surface Interval	Gas In (bar)	Gas (and manifold) check	Buoyancy check	Tools check	Computer set (Air/EANx)	Left Surface	Emerg	Bottom Time (min)	Max Depth (m)	Gas Out (bar)	Task/Purpose/Tools

Tab. 3

Surface-supplied SciDive LogSheet.

Surface-supplied SciDive LogSheet														
										[Daily SciDive Log no.]				
[Project name/Acronym_YYYYMMDD_#]				Pre-Dive				Post-Dive						
Diver name (add * if leader)	Dive team (#)	Surface Buoy	Reserve/bail-out: Pressure and size	%O <sub>2</sub> MOD	Reservoir Gas pressure (bar)	2nd stage check	Buoyancy check	Tools check	Computer set	Left Surface	Emerg	Bottom Time (min)	Max Depth (m)	Task/Purpose/Tools





## SCUBA & SURFACE-SUPPLIED SciDIVE LOGSHEET

On the one hand, logsheets of both diving modes bear some resemblances between each other, including information on the breathing gas mixture, which is typically air (O<sub>2</sub> 21%) but can also be Enriched Air Nitrox (e.g., EANx32, EANx36) where the Maximum Operating Depth (MOD) must be stated. Pre-dive checks include verifying gas (valves, second stages, hoses and pressure); buoyancy check (weight belt, buoyancy compensation device [BCD]); verifying all tools required for underwater work are being carried (e.g., underwater camera rig, quadrats, sampling bags, acrylic slates, transect tape, lift buoys); and that the diving computer is set up to the gas mixture accordingly. Once the diver is back on the surface, times are annotated (bottom, and total decompression times) and completed tasks are recorded including any other observation or event. On the other hand, some relevant differences exist between these two diving modes (Fig.1). According to [6] the minimum dive team for benign conditions using SCUBA is three: the supervisor (DS), diver and buddy; while it is four when using Surface-supplied: DS, tender, diver and stand-by diver [6]. SD is built under a team-based approach, therefore leadership (identified with an \* in the tables), chain of command, and tasks should be fixed prior to any dive and repeated during the pre-dive briefing.

The task of carrying the surface buoy should be assigned to one of the divers (buddy) and marked accordingly in the logsheet. This is mandatory for SCUBA because harsh seas, or surface reflections, may interfere with the surface team's ability to identify the divers' location by observing their bubbles as they break surface. Regarding gas containers, SCUBA depends on the use of cylinders as the source of gas mixture. These can be of aluminium (AL) or steel (S), and their volumes (l) can vary (e.g., 7, 12, 15 or 18), as well as the number of cylinders (singles, independent doubles or twinset) and their configuration (back-/side-mounted); while surface-supplied depends on an air compressor at the surface and the hoses acting as an umbilical connecting the components. To determine the consumption of breathing gas mixtures, 'Gas In' and 'Gas Out' (in bar or PSI) are key variables to record for better management and further planning. However, this is less accurate for surface-supplied diving. The person tending the equipment from the surface must make sure that the compressor pressure gauge reads between 8–16 bar (115–225 PSI) [24] and if any problem emerges tether signals should be used to communicate surface-to-diver and *vice versa* (e.g., [25]).

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## SciDIVER'S DIGITAL LOGBOOK

Once underwater, a proper logbook starts to be built when annotations and general *in situ* observations are recorded to either underwater slates (Fig.1b) or multimedia (ideally chronologically synchronised) ('Hyperlink to multimedia' in Table 4). The nature of the content of this logbook will much depend on the scientific discipline and objects of study, however, from an ecological point of view important and common annotations may include (i) biotope/habitat type (e.g., kelp forest/bed, barren ground, rocky/coral/artificial reef, seagrass meadows); (ii) substrate type (landslide rocks, boulders, cobbles, sands, muds), (iii) slope (vertical wall, plateau, overhang), (iv) rugosity [26]; (v) biocenosis attributes (densities, behaviours, interactions, rare sightings) and (vi) horizontal visibility. The *SciDiver's digital logbook* builds from the data recorded in the previous forms, but there are some fields that require revisiting the dive computer; these include max depth, average temperature, and temperature at max depth. Modern dive computers have either a data cable, an interface, or can wirelessly download data to a portable computer. These specs are very useful since the whole diving profile is kept there and it may offer key insights into diving incidents resulting in accidents or fatalities [18].

Research units conducting SD operations should take advantage of the automatic logging of electronic devices to systematically manage data collected during diving operations. The SciDive record forms represent an effort to do so using a bottom-up approach, building from a research unit operating in a country with an incipient (scientific) diving programme towards a more regulated occupational background.

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## DISCLOSURE STATEMENT

The author declares no conflict of interest.



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**Hoja de registro SCUBA SciDive**

[Nombre de proyecto / Acrónimo AAAAMDD #]		Pre-Inmersión				Post-Inmersión			Tarea/Propósito/Herramientas
Nombre de buzo (agregar * si líder)	Equipo de buceo (#)	Gas Ingreso (bar)	Emergió	Gas Salida (bar)	Tiempo de fondo (min)	Prof máx (m)			
	Boya de superficie	Verificación de Gas (manifold)							
	Tamaño de cilindro (L) y material (Aluminio/Acero)	Verificación de flotabilidad							
	Reserva: Presión y tamaño	Verificación de herramientas							
	%O <sub>2</sub> , MOD	Configuración (Aire/Nitrox)							
	Intervalo de Superficie	Abandonó superficie							

Registro SciDive Suministro en Superficie													
[Registro SciDive Diario no.]													
[Nombre de Proyecto/Acrónimo_YYYYMMDD_#]													
		Pre-Inmersión				Post-Inmersión							
Nombre de buzo (agregar * si líder)	Equipo de buceo (#)	Boya de superficie	Reserva/de rescate: Presión y tamaño	%O <sub>2</sub> , MOD	Presión de la reserva (bar) Ver. 2da etapa	Ver. flotabilidad	Ver. herramientas	Conf. computadora	Abandonó superficie	Emergió	Tiempo de fondo (min)	Prof máx (m)	Tarea/Propósito/Herramientas



