Food and Agriculture
Organization of the
United Nations

INTERNATIONAL YEAR OF
ARTISANAL FISHERIES
AND AQUACULTURE
2022

A PRACTICAL GUIDE ON SAFE HOOKAH DIVING

Diving for sea cucumbers and other marine organisms

Cover drawing: Massimiliano Lipperi
Cover photograph: Beatrice Longi

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2023

Required citation:
Buonfiglio, G. & Lovatelli, A. 2023. *A practical guide on safe hookah diving – Diving for sea cucumbers and other marine organisms*. Rome, FAO. https://doi.org/10.4060/cc3789en

ISBN 978-92-5-137476-4

Preparation of this document

This guide is being launched during the International Year of Artisanal Fisheries and Aquaculture (IYAFA) 2022, declared by the United Nations General Assembly at its Seventy-second Session in 2017. For this year, there is the overall international objective not only to increase global awareness about, understanding of and action to support the contribution of small-scale artisanal fisheries and aquaculture to sustainable development, but also to enhance social development and well-being of fishers and farmers alike. The IYAFA 2022 Global Action Plan, launched at the start of this year, aims to build global momentum to empower small-scale artisanal fisheries and aquaculture and secure a sustainable future for these important economic and social sectors.

Pillar 3 of the IYAFA Global Action Plan focuses on securing decent working and living conditions as essential for small-scale artisanal fishers, fish farmers and fish workers who seek to secure livelihoods and maintain their social, physical and cultural well-being, all recognized by the FAO Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (the SSF Guidelines). In particular, the SSF Guidelines indicate, "all parties should strive to ensure that occupational health and safety is an integral part of fisheries management and development initiatives". They also indicate, "States should address occupational health issues and unfair working conditions of all small-scale fishers and fish workers by ensuring that the necessary legislation is in place and is implemented in accordance with national legislation and international human rights standards and international instruments to which a State is a contracting party".

Beyond the SSF Guidelines, occupational safety and health (OSH) is a key component of FAO's work on Decent Rural Employment, as well as part of the One Health approach. In 2022, OSH was recognized by the International Labour Organization (ILO) as one of their Fundamental Principles and Rights at Work.

This practical guide on safe hookah diving, prepared as part of a project funded and implemented by the Food and Agriculture Organization of the United Nations (TCP/LIR/3801/C1) to assess the sea cucumber fisheries along the coast of Liberia, is intended both for public administrators, including fishery extension officers, and for fishers. For public administrators, it is necessary for them to regulate hookah diving to better ensure the physical well-being of all those engaged in this fishing practice. For the fishers, the intent is for them to acquire a basic theory on diving with compressed air, and receive practical training by a qualified diving instructor to carry out hookah diving in safety.

In many countries, the reality of artisanal fishers harvesting sea cucumber and other commercially valuable marine benthic organisms is nothing short of dramatic owing to unsafe working conditions. Countless people, often of a young age, find themselves employed in this sector despite receiving no training, utilizing insufficient, unsuitable and often dangerous equipment, and experiencing intense rhythms of work that violate dive rules. Accidents are common, with divers experiencing paralysis or death, consequently leaving their families in poverty and despair.

With some exceptions, there are often no rules imposed by competent public authorities, though governments should take responsibility for workers' occupational safety and health by enforcing compulsory training, providing medical care and tailored insurance schemes as well as setting out and enforcing appropriate rules and regulations for both independent divers and businesses employing such divers. Alternatively, governments should consider banning this activity until these conditions are met.

Strong commercial interests on the one hand and difficulties preventing many countries from intervening on the other, have mostly prevented hookah diving from being regulated or prohibited. As a result, the decision has been made to prepare a guide that provides fishery officers and divers with useful information to increase the level of awareness on safe diving practices under which these fishers can operate. It is a tool to understand what should not be done and what would be better to do, prepared in the knowledge that only qualified instructors in specific training can explain the complex subject of professional SCUBA and hookah diving. Therefore, considered as a guide rather than a manual, this document can decisively help avoid serious accidents for divers even if they are forced to dive for hours at greater depths. The choice was made to also include topics that should be entrusted to specialized training programmes, such as decompression.

Decompression sickness is the most common hazard among these fishers, a condition that can only be avoided in two ways: diving at depths for a limited time or making decompression stops. The first certainly does not respond to the interests of those who hire divers to look for resources in increasingly deeper waters, and therefore the second option remains to explore in detail. The guide therefore explains, even to those who have not had training by qualified instructors, why and how to perform decompression dives, proposing not particularly stringent decompression tables whose application would already be a big step towards the safety of this fishing practice.

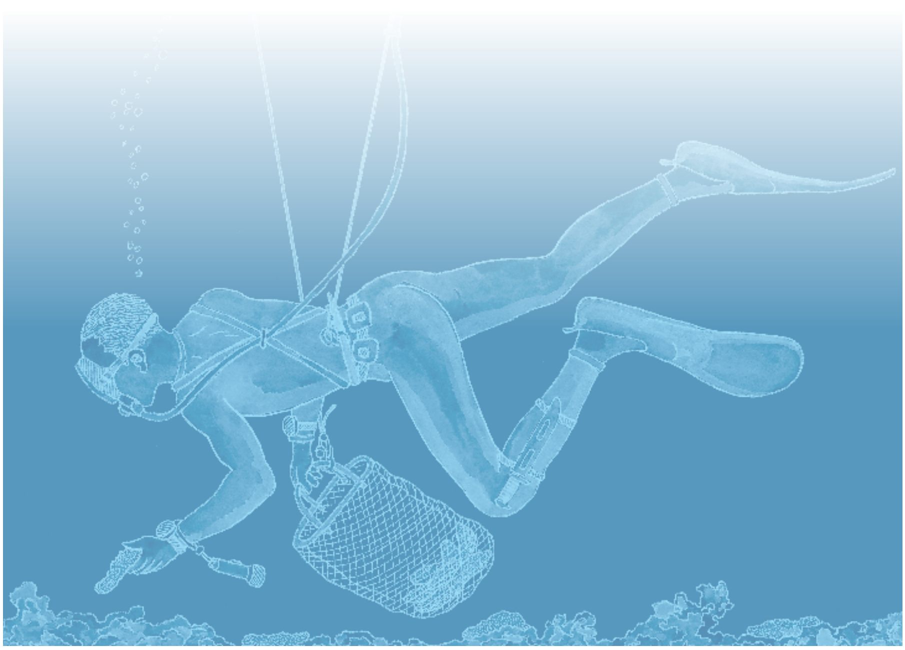
Abstract

The gathering of commercial benthic organisms from the seabed by underwater fishers is a growing activity in many regions in Africa, Asia, Pacific, Latin America and the Caribbean. Sea cucumbers are particularly targeted, as they are in great demand and command high market prices in Asian markets. Fishing and trading of these holothurians have attracted the interest of many people, particularly trade intermediaries, who often employ local fishers with little or no underwater diving experience. Generally poorly equipped, the fishers are often forced to work long hours with no concerns over their state of physical health and psychophysical suitability for the strenuous and dangerous activity of diving.

In many regions, sea cucumber fishers operate with compressed air supplied by hookah systems frequently powered by unsuitable or improvised compressors. Furthermore, because of the declining number of specimens in shallow waters in many fishing grounds, divers increasingly search for resources at greater depths and for prolonged periods, often unaware or ignoring dive decompression tables and other safe diving practices. Working under such poor conditions, often with inadequate support from the boat assistant, makes hookah diving a risky and unsafe activity. It may lead to accidents that may result in the death or permanent disability of fishers, who generally operate in locations far from medical facilities capable of providing hyperbaric treatment and first aid.

This guide aims at providing fishers, as well as fishery extension officers, with a tool to acquire the basic knowledge needed to carry out hookah diving safely. Through simple language and numerous illustrations, the guide describes the basic rules of diving, the potential risks associated with this activity and what to do to minimize them, as well as other useful tips to improve hookah diving operations. The guide, however, is not intended as a comprehensive manual for commercial divers. Rather, it is strongly recommended that fishers who want to engage in hookah or SCUBA diving receive appropriate training by a qualified diving instructor.

The guide is divided into two parts. The first part is intended for fishery extension officers to help them understand the risks of hookah and SCUBA diving and to provide them with information that should increase good practices for this type of fishing. The second part is intended for the fishers themselves; it outlines the risks associated with hookah diving and recommends practices that should help prevent any work-related accident associated with this diving practice.



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Acknowledgements

This practical guide received constructive comments and suggestions from a number of divers who have practiced diving and some who also have taught as qualified instructors for many years. We wish to acknowledge the contributions, suggestions and comments received from Austin Stankus, Mirko Bruni and Ileana Grandelis at the Food and Agriculture Organization of the United Nations (FAO). External experts who have also contributed to the preparation of the manual include Sebastián Herrera-Kasic from Chile, and Francesco Cardia and Luca Lucarini from Italy. Thanks are also due to the professional Marco Polo Diving Center in Rome for the valuable advice and technical and operational information shared with the authors.

We acknowledge the encouragement received from the National Fisheries and Aquaculture Authority of Liberia and, in particular, from its Director-General, Ms Emma C. Metieh Glassco, on the importance in preparing this guide. Appreciation is also due to the staff at the FAO Representation in Liberia and the FAO Subregional Office for West Africa in Senegal, particularly Paula Anton, Fisheries and Aquaculture Officer, for their support and project coordination.

A special thank you goes to Tom Collison, Abdulai Mansaray and Charlie Cole for sharing information as well as providing photographic images of sea cucumber fisheries and fishers operating off the coast of Liberia. Massimiliano Lipperi (@studiowildart) applied his artistic talent to producing all the striking illustrations included in the guide. Graphic design and layout was carried out by José Luis Castilla Civit. Our appreciations also go to Caroline Bennett for the initial translation of the draft manuscript into English and Maria Giannini and Andrew W. Moore for the final language editing.

A special thanks also goes to the sea cucumber hookah fishers who have shared their experiences. We hope that this guide will be of assistance in helping them to better understand the physics of diving, to know the effects that water pressure has on the human body and to practice their activity in safety.

Finally, we wish to acknowledge Cressi Sub SpA and Mares SpA, two established manufacturers of water sports equipment in the world serving the SCUBA diving industry, for the quality photos provided.

Conversions

Metric units		Imperial units
Length		
1 metre (m) = 100 centimetres (cm)		1 foot (ft) = 12 inches (in)
1 m	=	3.28 ft
30 cm	=	1 ft
Weight		
1 kilogram (kg) = 1 000 grams (g)		1 pound (lb) = 16 ounces (oz)
1 kg	=	2.2 lb
453 g	=	1 lb
Volume		
1 litre (L) = 1 000 millilitres (ml)		1 pint (pt) = 20 fluid ounces (fl oz)
1 L	=	1.76 pt
568 ml	=	1 pt
Area		
1 square metre (m^2) = 10 000 square centimetres (cm^2)		1 square foot (ft^2) = 144 square inches (in^2)
1 m^2	=	10.76 ft^2
0.093 m^2	=	1 ft^2
Pressure		
1 bar = 1.0197 kilogrammes per square centimetre (kg/cm^2)		1 pound per square inch (psi) = 144 pounds per square foot (psi/ft^2)
1 bar	=	14.5038 psi
0.0689 bar	=	1 psi

INTRODUCTION

The preparation of this basic guide, its limits and purposes

The aim of this guide is to describe key concepts and provide useful guidance and advice. It is intended for fishers who harvest organisms from the seabed using hookah systems and for fishery extension officers who supervise these activities. This guide draws attention to the safety concerns with this diving technique and provides practical recommendations. However, this guide does not replace the necessary training fishers should receive before engaging in hookah diving (or SCUBA – which is short for self-contained underwater breathing apparatus – diving). **No fisher should engage in this activity without training from a qualified diving instructor**.

Practiced in many countries, the hookah diving technique is driven by strong demand for commercially valuable bottom-dwelling marine organisms (sea cucumbers, for example), which fetch high prices internationally, mainly in Asian markets (**Plate 1**). Entrepreneurs who are attracted by the lucrative trade often

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PLATE 1. Dried sea cucumbers sold in an Asian store.

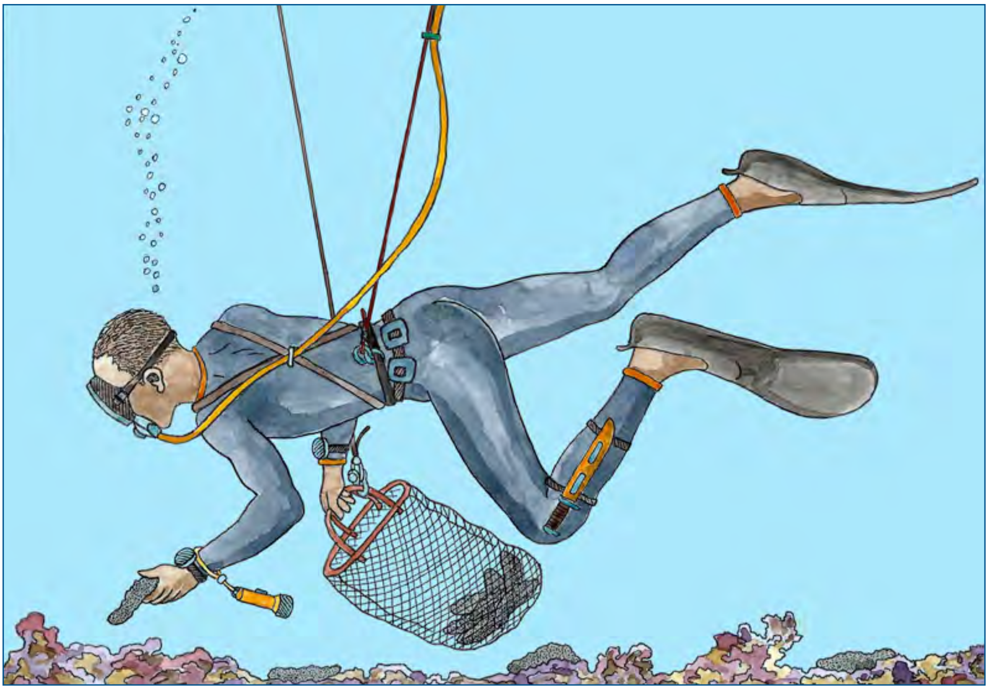


FIGURE 1. Diver collecting sea cucumbers on the seabed. Note the correct personal equipment and the appropriate surface connections: lifeline, hookah hose secured to the back and catch basket recoverable from the boat.

attempt to pursue this activity with minimal investment, recruiting divers who have little or no equipment, training or experience (**Figure 1**).

Hookah divers often lack adequate training and are provided or have access to poor quality, makeshift dive equipment. Such failings, together with the often long working hours, and often unhealthy lifestyles, cause numerous accidents that lead to the death, paralysis and/or disability of a growing number of fishers that many times go unnoticed by the health or other relevant authorities.

The fishers' earnings are often proportional to the amount of product fishers harvest, meaning that to earn more they must dive repeatedly, working consecutive days (even at night) at ever-greater depths, as sea cucumbers and other bottom dwelling resources (the queen conch, *Aliger gigas*, in the Caribbean, for instance) become scarce in shallower waters. Fishing activities therefore intensify, and the depths the divers reach increase, with no precautions taken to prevent decompression sickness, which many artisanal fishers generally know little or nothing about.

This often unregulated business is a growing problem for which the authorities are largely unprepared. In all but a few cases, legal frameworks to regulate businesses or to authorize professional divers do not exist. In addition, healthcare resources are lacking when accidents occur. In most cases, divers who die or become disabled do not have insurance, compensation or support, and their families are left alone to deal with the loss of their primary source of income.

Consequently, the need arose for this basic guide, which has two functions:

(i) to provide fishery extension officers with a useful tool to positively engage stakeholders at all levels, including regulatory bodies and entrepreneurs; and

(ii) to provide fishers with technical information and safe diving practices relative to hookah diving as well as guidelines on how to work safely.

This basic guide is for general informative purposes only. **It is not a diving manual**; it merely describes risks, provides advice and outlines good practices for hookah diving **up to a depth of 20 metres**, with the aim of improving safety standards. Training of divers by a qualified instructor is needed before divers engage in this activity.

The guide focuses on **PREVENTION**, mainly because hookah fishing is practised in remote areas far from medical support. The aim is to raise awareness of the risks associated with diving using compressed air, as in the case of hookah and SCUBA diving. If fishers are aware of these risks and receive training before engaging in the activity, it would reduce the incidence of diving accidents, which require swift treatment, trained people and use of decompression chambers.

Sea cucumbers and other marine organisms harvested by hookah divers are subject to risks deriving from unregulated exploitation, potentially threatening the sustainability of a fishery. As a result, the continuity of this fishery activity and the livelihoods of those involved may also be endangered.

Although the formulation of management plans is beyond the scope of this guide, clearly, conservation measures are important, some of which introduce minimum conservation reference sizes, maximum allowable daily catches, total allowable catches, rotation of fishing zones, closed seasons, and minimum and maximum fishing depths.

- **Any activity that involves diving must follow specific rules to ensure compliance with minimum safety standards.**
- **The diving equipment used must be appropriate for the activity and must conform to the specifications guaranteed by the manufacturer.**

IMPORTANT

- **The use of alternative or unsuitable equipment is strongly discouraged, as this can lead to serious consequences for the user's health, including death.**

Structure of the guide

This basic guide consists of two parts:

PART 1 provides fishery extension officers with a general overview of harvesting practices by divers using hookah systems and highlights the issues that need to be addressed to make hookah diving a safe livelihood activity.

Health and safety, training, equipment, first aid, medical treatment, and fisheries management are all briefly covered so that fishery extension officers can recognize any shortcomings and can adequately address problems when they occur. These include:

- issues related to institutions that are in charge of regulating diving activities as well as providing support in terms of healthcare and insurance;
- issues related to the businesses that are responsible for how fishing activities are carried out, the equipment used, the procedures and time schedules followed, as well as for the divers' health and their technical training; and
- issues related to the fishers, who need to be aware of the risks involved in working in breach of the safe diving practices and without proper equipment, and how important it is to be healthy in order to perform such a physically demanding job.

PART 2 is designed specifically for underwater fishers, to provide them with basic guidance, to increase their awareness of the risks inherent in diving activities and the possible ways they can increase safety standards, and to communicate the importance of being healthy in order to perform such physically demanding work. Only through education will divers be able to discern the conditions and learn about acceptable equipment so that they can conduct their work in safety and be empowered to adequately negotiate with companies engaging their services.

In order to make the guide as user-friendly and accessible as possible, extensive illustrations and examples are provided to improve understanding among readers with limited literacy.

Moreover, this part of the guide provides fishery extension officers with information on good diving practices to help raise awareness and inform fishers regarding the many technical aspects covered in this guide, which under the right conditions could serve as useful material for basic training.

1. Safety in professional diving

Safety for all divers, and for professional divers in particular, is based on three main premises: (i) good health and a healthy lifestyle; (ii) technical expertise through training and experience; and (iii) the correct use of well-functioning equipment. When divers meet these three conditions, all the difficulties associated with working in an underwater environment can be dealt with correctly and safely.

Divers should be especially attentive to four key phases: (i) planning the dive; (ii) complying correctly with dive times and depths according to dive tables or to the information displayed on dive computers (see box in Section 4); and (iii) adopting safety procedures that facilitate the operation from the moment divers enter the water to when they resurface; and (iv) compliance with official diving regulations, if any.

In remote areas, because suitable healthcare facilities are located too far away to assist with emergencies, it is particularly important to minimize risks and implement high safety standards. It is imperative to avoid situations in which a serious medical emergency causes death or disability.

Although divers should be the first to be concerned about their health and ensure that they are fit to dive, fisheries officers should also be responsible for ensuring that the divers receive appropriate training and have knowledge of the equipment to use. Fisheries officers should therefore review the second part of the guide carefully. Medical personnel should be responsible for divers' medical fitness and certifications. Subsequently, the relevant maritime authority should then authorize the fitness documents and certifications and forward them to the divers' employer for assessment.

Lastly, it is essential that the on-board diver's assistant (the skipper of the diving support vessel) is also trained in all key operating procedures and techniques, as the safety of the entire activity depends largely on the assistant.

SAFE DIVING

- **Good health and a healthy lifestyle** – ensuring you are physically fit for diving.
- **Technical expertise** – knowing what you are doing and how to do it.
- **Use of appropriate and efficient equipment** – only using the right equipment.
- **Support vessel** – relying on the on-board assistant and breathing good quality air from the compressor using a hookah hose.

2. Health requirements of divers

Life at sea level exists at a pressure of 1 atmosphere (atm) – that means the column of air stretching above a human head weighs about 1 kg per square centimetre. When a diver descends into water, the weight of the water column above the diver adds to this air pressure or weight. A 10-metre water column weighs as much as a column of air as high as the Earth's atmosphere. At a depth of 10 metres, the pressure felt by the diver is double that at sea level. At 20 metres it will be equal to 3 atm (one of air plus two of water), 4 atm at 30 metres (one of air plus three of water), and so on (**Figure 2**).

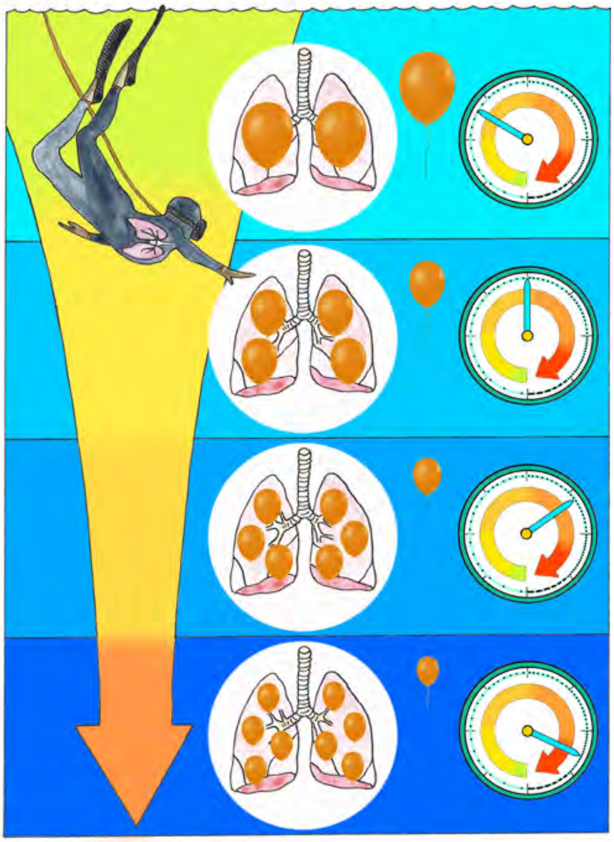


FIGURE 2. Reduction of gas volume as ambient pressure increases with water depth. At constant temperature, the volume occupied by a gas is inversely proportional to the absolute pressure. For this reason (Boyle-Mariotte Law), the volume of air in the lungs or in a balloon will decrease with increasing depth. The volume of air in each breath does not change with depth, but if a diver needs 500 ml air/breath when at sea surface (1 atm), to fill the lung volume the diver will now need double the amount of air when at 10 m (2 atm) – where the air volume will be reduced by half; 1 500 ml at 20 m (3 atm) – where air volume will be reduced to one-third; and 2 000 ml at 30 m (4 atm) – where the air volume will be reduced to a quarter. This explains why surface supplied diving requires more air at increasing depths and why SCUBA tanks have a shorter supply duration.

The first basic requirement for diving is good health and a healthy lifestyle. Because of the way the human body adjusts and responds to increased pressure and given the demanding skills needed, good health is required to work underwater. Any illness that may interfere with normal activity can pose severe problems when diving.

Anyone planning to work underwater should undergo a full medical examination, including a chest X-ray and, ideally, a hyperbaric test to check for ear and sinus problems as well as for susceptibility to claustrophobia.

Specifically, the physician should thoroughly examine the respiratory system. People with emphysema and asthma are at higher risk of rupturing their lungs. Moreover, unknown residual damage from past illnesses such as pneumonia, tuberculosis and spontaneous pneumothorax can make the diver susceptible to gas embolism or associated disorders.

Any myocardial pathology or coronary disease makes diving dangerous as, frequently, this activity causes heart rhythm disturbances. Hypertension, along with pharmaceutical therapies used to treat the condition, is a significant risk factor, if not an outright contraindication to diving.

Gastrointestinal disorders, when these include ulcers or the tendency to vomit, can be dangerous because of possible haemorrhage or perforation of the mucous membranes. Diabetics with associated circulatory and neurological complications are strongly discouraged from diving, as are individuals with any form of epilepsy, diabetes or obesity.

Medical examinations and fitness assessments should be carried out at least once a year and repeated often if the diver's state of health has been compromised (Annex 1). Such assessments should become more frequent with age.

Divers should be in charge of their health, hydration and nutrition, as neglecting these can increase the risk of injury and can exacerbate life-threatening conditions. Certification of medical fitness is also essential if the social security system in the country in question has life insurance, permanent disability and accident insurance schemes for divers.

Importantly, the use of drugs, smoking or alcohol are all strongly discouraged and are to be avoided in the 24 hours before a dive and the 12 hours after.

Children below 18 years old should not be engaged in professional diving. According to the ILO Recommendation No. 190 on the Worst Forms of Child Labour, work underwater falls in the definition of "hazardous work". Therefore, any child diving for work would be considered in child labour.

ATTENTION

- **The use of drugs, smoking and/or drinking alcohol are not compatible with diving.**
- **Medical fitness of a diver needs to be assessed and certified by a physician periodically.**

3. Minimum technical knowledge

The second basic requirement for diving is technical expertise. Commercial divers should possess: (i) an awareness of the risks associated with diving; (ii) knowledge of basic physiological aspects; (iii) diving techniques; and (iv) an understanding of how to operate and maintain equipment. These skills are important and can make a difference in life-threatening situations.

It is extremely dangerous for inexperienced divers to attempt to act as professional divers if lacking adequate training, a minimum level of technical knowledge, and awareness of the physical and physiological processes involved and the changes that occur when breathing air at high pressure.

Sometimes, ill-prepared underwater fishers shrug their shoulders with resignation and accept joint pain, tingling sensations in their hands and feet, ear or nose bleeds, nausea, headaches or other aches and pains as normal consequences of diving; the fact is that these injuries or conditions can lead to long-term problems. In fact, many of these problems can be prevented with appropriate training. Some divers think they are immune or invulnerable. Divers must not only overcome this resistance, but they also must accept learning the basics. Moreover, a compulsory examination to test the diving competencies of fishers to work underwater should be required.

These individuals must understand that when diving is carried out according to the rules and safe diving practices it does not result either in any short- or long-term consequences or pain. If divers experience pain, it means something is wrong, and they must stop diving and seek treatment before returning to the water.

This basic guide includes a simple questionnaire for divers to assess their level of competence and grasp of the minimum technical knowledge required to dive (see Annex 2). The assessment can support those who are supervising the divers' activities. This knowledge is essential for fishers who intend to work underwater. It can make the difference between continuing to live a normal life, or suffering disability or death. Fishers lacking this knowledge are strongly advised against working underwater until they receive appropriate training. In many countries, these fishers would be banned from diving since working before attaining proper knowledge is comparable to driving a car without passing a driving exam and obtaining a driving licence. Receiving training from a qualified diving instructor is by far the best way fishers can acquire sufficient knowledge and experience to work underwater.

Raising awareness among hookah fishers is important. For instance, former divers, particularly those who have become disabled because of diving accidents, can play a key role in sharing their experience. They are living examples of mistakes having been made while participating in this activity.

ATTENTION

- **Safe diving depends on knowledge of the risks and safe diving practices.**
- **Underwater, ignorance kills.**
- **Disregarding basic safe diving practices can easily lead to paralysis or death.**

4. Appropriate equipment

The third basic requirement is the correct use of well-functioning equipment to ensure proper health and safety standards. Some hookah divers, regrettably, still disregard the importance of this requirement, and many still dive regardless of inadequate equipment.

Essential diving equipment includes, but is not limited to, a mask, snorkel, fins, weight belt (with quick release system), wetsuit or other protective suit, diving knife, dive watch, torch and depth gauge (see Annex 9). Additional safety equipment may include a dive computer, a buoyancy control device (BCD) and a bailout cylinder (SCUBA).

DIVE COMPUTER

The dive computer is a sophisticated electronic instrument that records the time and depth of a dive and, as a function of these, the level of nitrogen saturation in the body tissues. It displays such information as the time available prior to resurfacing without the need for decompression or, if the time limits have been exceeded, the time and depth at which to make decompression stops before resurfacing. However, dive planning and the use of the tables remain important to: (i) calculate the required air supply when SCUBA diving; and (ii) to add the increases to the tables to take into account the greater accumulation of nitrogen resulting from dives carried out under particularly cold and fatiguing conditions even with hookah (see Box on page 34). Dive computers found in the market are normally calibrated to the latest generation of decompression tables (see Note on page 15).

BUOYANCY CONTROL DEVICE

The buoyancy control device (BCD), allows the diver to control buoyancy at various depths, remaining neutral, positive or negative at any depth by inflating or deflating the device from the diver's cylinder through a flexible inflator hose. A BCD is an important piece of equipment for divers who must operate in open water at intermediate depths, or close to the bottom where it is necessary to maintain negative buoyancy. It is also used as a device to keep the diver afloat in a resting position or if an emergency occurs (physical fatigue, for example) before being reached by the support vessel. However, the BCD must be used with caution, mainly to avoid ascents at an uncontrolled speed if the air is not discharged from the device as the depth decreases. The use of the BCD therefore requires specific training.

Poor or inadequate equipment leads to shortfalls in safety, increasing the risk of accidents, resulting in possible paralysis or death. Safety highly depends on the equipment used. The rule is "all-or-nothing": either everything is present, well maintained and in full working order, or, if something is missing or unfit for use, diving cannot be done safely and the dive(s) should be aborted.

These technical aspects can make the difference between life and death for divers. Knowingly operating below safety standards inevitably means taking responsibility for the possible consequences.

This basic guide provides information on hookah diving apparatus and personal equipment together with indications on how to experience diving safely. Also covered are alternative solutions when problems arise and what to do when suitable personal equipment is unavailable (see Sections 4.1 and 4.2). Departing from these criteria, or accepting compromises, will lower safety standards and result in outright non-compliance. This guide is what the name implies, a guide, and is not a manual on how to apply diving/hookah techniques. It is not a replacement for training by a qualified instructor, which is an essential requirement for safe diving.

ESSENTIAL

- **Appropriate, efficient personal equipment for each diver is an essential prerequisite to work underwater.**

5. Operational safety measures

In terms of operations (see Part 2, Section 4), there are various techniques and solutions that can facilitate the diver's work, reduce exposure to physiological stress and increase safety standards. Much of this depends primarily on the person who operates the support vessel and assists the diver, from the preparation of the dive to the moment when the diver resurfaces and climbs back aboard the vessel.

Each phase requires the active participation of the on-board assistant, who is responsible for operating the vessel and other tasks. These include:

- deploying the surface/bottom rope for the descent/ascent of the diver;
- releasing and recovering the air intake hose secured to the lifeline;
- checking air delivery;
- where there is an on-board compressor, checking that the air intake is always upwind of the engine exhaust outlet;
- checking the maximum depth actually reached by the diver;
- checking the total dive time (bottom time) and decompression stops;
- at intervals, retrieving the bag containing the harvest and returning it to the diver; and
- administering first aid and understanding emergency management.

The assistant's role is that of an active, competent partner for the diver and together they form an operational unit. Although assistants are not directly exposed to the risks and stress of underwater work, they are crucial to the success of the fishing trips.

It is therefore **essential** for the assistant to receive the same technical training as the diver, while also complying with all the safety procedures, methods and operating standards. The assistant must also abstain from using drugs or drinking alcohol.

A good solution is to hire former divers who are no longer actively involved in underwater activities, owing to minor disabilities or age, to assist on-board the vessel.

ESSENTIAL

- **The assistant on the support vessel needs to have the same level of expertise as the diver; together, they form an operational unit on which the safety of the underwater fishing operations depends.**

6. Emergencies and first aid

As stated in the introduction, this guide is more about prevention of accidents rather than treatment for what can happen to a diver who has not followed safe diving practices.

Treatments for certain medical emergencies need to be administered immediately (cardiopulmonary resuscitation – CPR, for example), while others can be administered within a few hours (recompression using decompression treatment tables by a qualified medic, for example). Frequently, however, some treatments are not available or impossible to deliver on site and under the conditions where this type of diving activity normally takes place.

The most frequent conditions and their treatments are listed below for information purposes only (see also Annex 3).

These treatments account for the varying circumstances and levels of competence in hyperbaric medicine across the health services of different countries, as well as the cost of medical treatment for injured divers, which is often borne by their families, as there is generally no insurance coverage. Making institutions aware of the need to protect these workers is one of the key priorities for the sustainable development of diving activities.

Ear injuries (otic barotrauma)

Otic barotrauma is a type of ear damage caused by pressure differences between the middle ear and the outer ear due to a failure to equalize (obstruction of the Eustachian tubes) either side of the eardrum. The pain becomes increasingly intense as the pressure difference increases. The eardrum bends towards the middle ear until it ruptures, causing dizziness, sometimes loss of consciousness, and bleeding. In most cases, these injuries heal simply by resting for 15 to 20 days (and refraining from diving for at least two months). Medical treatment is required if the injury becomes infected. Repeat injuries may result in some degree of permanent hearing loss.

Sinus damage (frontal and paranasal sinus barotrauma)

Sinus damage can occur because of the pressure differences between the sinus cavity and the external environment, often from obstruction of the sinus channels due to the presence of mucus or inflammation of the mucous membrane lining them. The damage may be acute, more or less serious and persistent, with constant or occasional pain. Treatment requires a medical doctor.

Negative pulmonary barotrauma

The respiratory system is impaired owing to the difference in pressure between the lungs, which are at a lower pressure, and the external environment. A diver equipped with cylinders or a hookah apparatus can suffer from this when the air supply runs out or is interrupted by some kind of technical failure. The subsequent inflow of blood into the lungs (pulmonary oedema) can be fatal, also because the ribcage can be crushed. In mild cases, symptoms include shortness of breath, facial congestion and loss of consciousness. Medical intervention is essential. In the event of asphyxia, mouth-to-mouth resuscitation should be carried out immediately (without aggravating lung damage), and inhalation of oxygen and absolute rest.

Traumatic gas embolism (positive pulmonary barotrauma)

Lung overexpansion injuries may occur during ascent when the diver stops breathing and holds air in the lungs. The air in the lungs expands as the pressure decreases, causing damage and altering the heart rate and breathing rate. The increased pressure in the lungs will compress the heart and the main blood vessels, preventing normal circulation of blood to the brain, leading to a drop in blood pressure and potentially causing death.

Rupture of the pulmonary alveoli causes bubbles to pass into the bloodstream, potentially resulting in gas embolism, damage to the pleura, pneumothorax or subcutaneous emphysema. The individual experiences various symptoms: chest pain, coughing with blood in the sputum, confusion, paralysis, visual disturbances, loss of consciousness and muscle seizures. Loss of consciousness may occur after resurfacing. In the event of cerebral and coronary embolism, loss of consciousness is rapidly fatal and unresponsive to any attempt at resuscitation. In non-lethal cases, disability is a potential consequence. Medical treatment is essential, pending hyperbaric oxygen therapy in a recompression chamber.

Decompression sickness

Bubbles forming in the blood and tissues cause decompression sickness. Depending on their location and size, the bubbles produce effects that vary from mild to extremely serious disorders, even death. This can occur during or following decompression owing to the extra nitrogen molecules that have dissolved in the blood and tissues while underwater. As the outside pressure decreases again, the accumulated nitrogen that cannot be dissipated forms bubbles. This occurs when the ascent is too rapid or when the diver fails to carry out decompression stops before resurfacing, or if the stops are not performed correctly.

The time it takes for symptoms to appear after the end of the dive can vary, but effects are always present within 12 hours (in 50 percent of cases within 30 minutes). The bubbles may form in the tissues of various organs or in the blood. Those in blood vessels can cause heart attacks, blood stasis or haemorrhages, while bubbles that form in the various organs and systems cause a range of disorders depending on the areas affected. According to the severity of the case, the following types of decompression sickness can be observed:

- **Painful form:** 4–8 hours after resurfacing; it affects the joints (knee, ankle, wrist, shoulder and elbow). The sickness subsides within 3–4 days, while fading gradually and ceasing in 1–2 weeks. This form may arise following long, strenuous dives, even at relatively shallow depths.

- **Paralytic form:** rapid onset (30 minutes) after resurfacing, with paralysis of one or more limbs developing following pain and general malaise. This form can also cause bladder and rectal paralysis and impotence, blindness, apoplectic seizures, loss of consciousness, coma and symptoms of heart failure. If the patient survives, permanent damage is possible.

- **Asphyxia or fulminant form:** this may arise following sudden ascent from a deep, strenuous dive, with severe symptoms occurring on resurfacing or within a few minutes – coronary embolism with sudden violent pain in the chest and loss of consciousness. Death is caused by mechanical asphyxia.

A diver with suspected gas embolism should receive recompression treatment as quickly as possible. Depending on the severity of case, treatment times vary. The success of this therapy depends on how quickly recompression treatment can begin. The decision to take a diver with symptoms of gas embolism to the nearest recompression chamber to begin a treatment schedule (which ranges from 2 hours 21 minutes to 38 hours 11 minutes in the most severe cases) only makes sense if the chamber is located nearby and can be reached quickly (2–4 hours).

UNDER EXTREME CONDITIONS: If there is no hyperbaric facility in the area, recompression at sea may be attempted, which entails the diver returning to a depth of up to 30 metres to put pressure back in the body and compressing the gas back into solution, after which the diver resurfaces slowly with extra safety stops to decompress correctly. This treatment lasts approximately 2 hours, starting at a maximum depth of 30 metres. When rapidly evaluating this option, given that interrupting the treatment would only aggravate the casualty's condition, the following must be taken into consideration:

- the feasibility of supplying air from the support vessel for the entire duration of the treatment;

- the physical and mental state of the diver (for example, shock, hypothermia, pain);

- suitable, stable weather conditions, with no strong currents;

- the availability of another diver, who can communicate with the on-board assistant, to help out the victim; and

- the achievability of lowering the injured diver to a depth which provides relief from the symptoms (never deeper than 30 metres) before ascending to the correct depths to make the decompression stops (see table on page 38):

The success of this method remains uncertain, however, and depends on the severity of the embolism.

Regarding decompression sickness, the best strategy is always prevention, achieved through strict adherence to the dive tables (Annexes 4–7) (see note below), allowing additional time in the event of subsequent dives due to residual nitrogen left in the blood from the previous dive. However, other factors that can cause the onset of decompression sickness need to be considered before hookah diving, such as the diver's age, fatigue, lack of sleep, obesity, alcohol abuse, various ailments and the coldness of the water.

IMPORTANT

- **Where medical emergency and hyperbaric therapy facilities are non-existent or far away, safety standards must be established to prevent accidents to the greatest possible extent.**

NOTE

- **This basic guide was prepared to raise awareness of fundamental rules, such as the importance of decompression tables, which are still widely ignored by many hookah divers. As such, it was deemed appropriate to propose tables that have been used for many years although not of the latest generation. Recent revisions of the same tables, in fact, show much longer decompression stops for shorter diving times. Once the decompression tables are consistently used in dive planning, fishery officers may propose the adoption of more recent tables (for example, United States Navy, Rev. 7), which can be freely downloaded from the Web.**

7. Fisheries management

Underwater fishing activities, even when they are carried out in compliance with established fishery management rules and regulations, represent the harvesting of naturally occurring marine organisms. The renewability of the resources targeted can, therefore, only be ensured when appropriate management measures are put in place and consistently monitored by the relevant governing authorities.

Measures and information, such as maximum daily catch quantities, total annual allowable catches, minimum conservation reference sizes, rotation of fishing areas, seasonal closure periods, minimum and maximum fishing depths and others, need to be included in management plans to prevent stocks from being overexploited and to protect biodiversity. The aim is to guarantee the sustainability and continuity of the fishing activity, preventing overfishing and ensuring that the species does not disappear from the fishing areas in question.

To ensure continuity of fishing activities and to safeguard employment and support the economy of fishing communities, authorities need to monitor fishing activities and collect and analyse data in collaboration with scientific institutions such as universities and research centres.

Management measures also include the issuance of fishing licences by the local government, in liaison with the maritime authority, and the department of employment and social security where diving authorizations are concerned. In this way, local authorities can monitor and regulate the intensity of fishing effort on the one hand while also limiting accidents by only authorizing healthy divers who possess the necessary technical expertise and suitable equipment.

1. What divers need to know to avoid getting hurt

When divers go underwater and breathe compressed air, they need to take various precautions and follow strict safe diving practices. If these practices are not followed, all kinds of accidents, injuries and serious illnesses can occur while they are breathing compressed air underwater.

The quality of the air, the maximum depth of the dive, the time spent on the seabed, the temperature of the water, changes in breathing rates due to fatigue, and observing the correct descent and ascent speed are all factors that can have serious, even fatal, consequences if not considered when preparing, planning and carrying out a dive.

The diver needs to be healthy, properly equipped and well assisted by the support vessel. Taking extra precautions is essential when there are strong currents, bad weather and other conditions that complicate communication between the diver and the support vessel. Each dive needs to be planned with all these factors in mind.

Communication between the diver and the assistant on the support vessel is through a lifeline cord (Note: the lifeline can be secured to the harness, to the arm of the diver or elsewhere as long as it is easily reachable by the diver to communicate with the boat assistant); the hookah hose (also known as the air supply hose or the umbilical cord) is also attached to this lifeline. Communication consists of a series of signals that have been agreed in advance between the diver and the assistant.

FOR EXAMPLE:

Assistant to diver: 1 pull	►	Everything OK?
Diver to assistant: 1 pull	►	(Answer) Yes, everything is OK.
Diver to assistant: 2 pulls	►	Retrieve lifeline; I am approaching the boat.
Diver to assistant: 3 pulls	►	Retrieve the basket.
Assistant to diver: 4 pulls	►	Bottom time will be over in 3 minutes (return to the rope to start ascent).
Assistant to diver: 4 + 1 pulls	►	Decompression stop completed, return to surface.
Diver to assistant: 3 + 3 pulls	►	Emergency! Coming up!

Planning each working day is essential. Both divers and assistants should know, in advance, the maximum depth of the dive, the time to be spent on the seabed and, if necessary, any decompression stops (**Annex 8**). All necessary operations must also be well organized, which involves anchoring the vessel and the cable for descent and ascent, organizing the spaces on-board for the diver, storing the catch, and deploying/rewinding the lifeline and hose without any part accidentally getting stuck. The lifeline must always be kept taut and held by the assistant, who must detect signals sent by the diver or send signals to the diver (**Figure 3**).

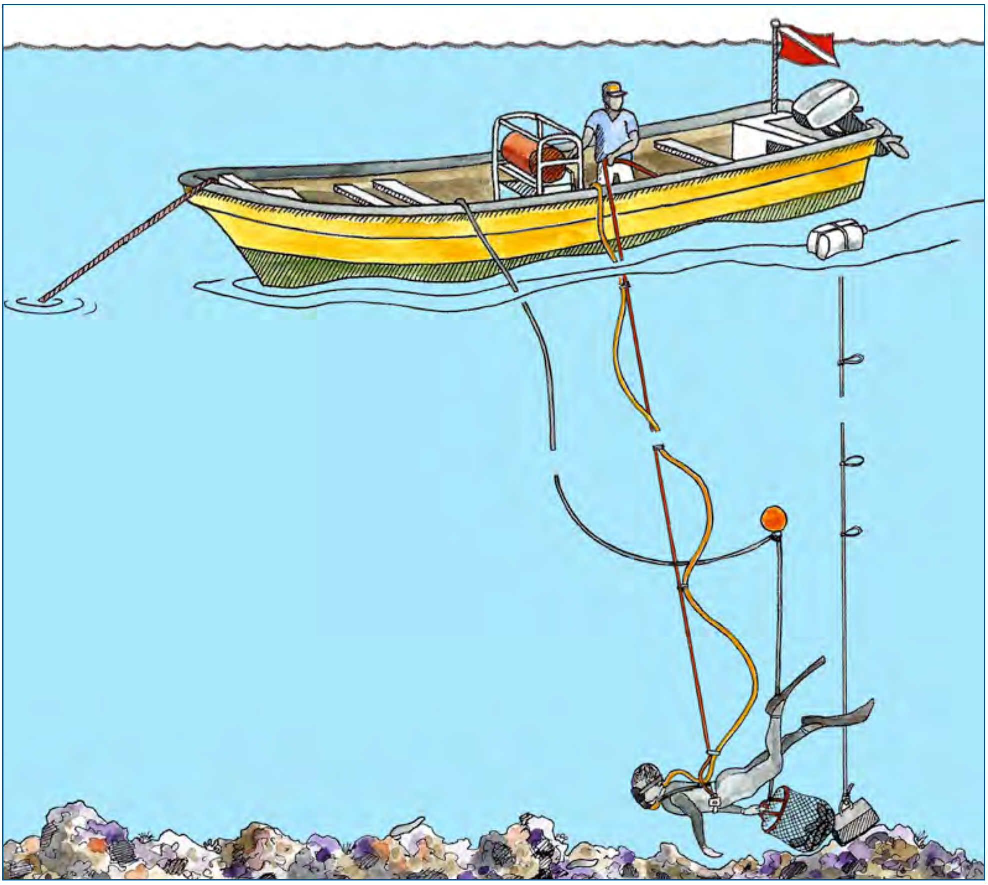


FIGURE 3. Support vessel with the assistant communicating with the diver at the seabed through a lifeline. Note that while the lifeline is kept taut by the assistant in the boat, the hookah hose is secured loosely to the lifeline to prevent tension and entanglement.

IMPORTANT

- **For your safety, learn, respect and apply safe diving practices, and make sure that you have the right equipment and that the equipment works. Plan your dive. If you fail to plan, you plan to fail.**

2. Breathe in good compressed air

To work underwater, having good quality air is vital. Air can be provided from a compressor or a supply tank that is sufficient to ensure that the diver has time to harvest enough resources to justify a day's work. However, the time spent working on the seabed must not exceed the limit, which, depending on the depth reached, allows the diver to ascend to the surface without making decompression stops. If the diver exceeds this limit, it is fundamental to have an air supply that is sufficient to make the necessary decompression stops.

The air needed to work underwater can come from different sources: the air can be contained in high-pressure cylinders carried on the diver's back (self-contained underwater breathing apparatus, known as SCUBA), supplied from the surface by a group or bank of cylinders filled on shore and placed in the support vessel, or by a compressor using a hookah hose (**Figure 4**). In all cases, the pressure of the air which flows into the mouth of the diver is reduced by a regulator.

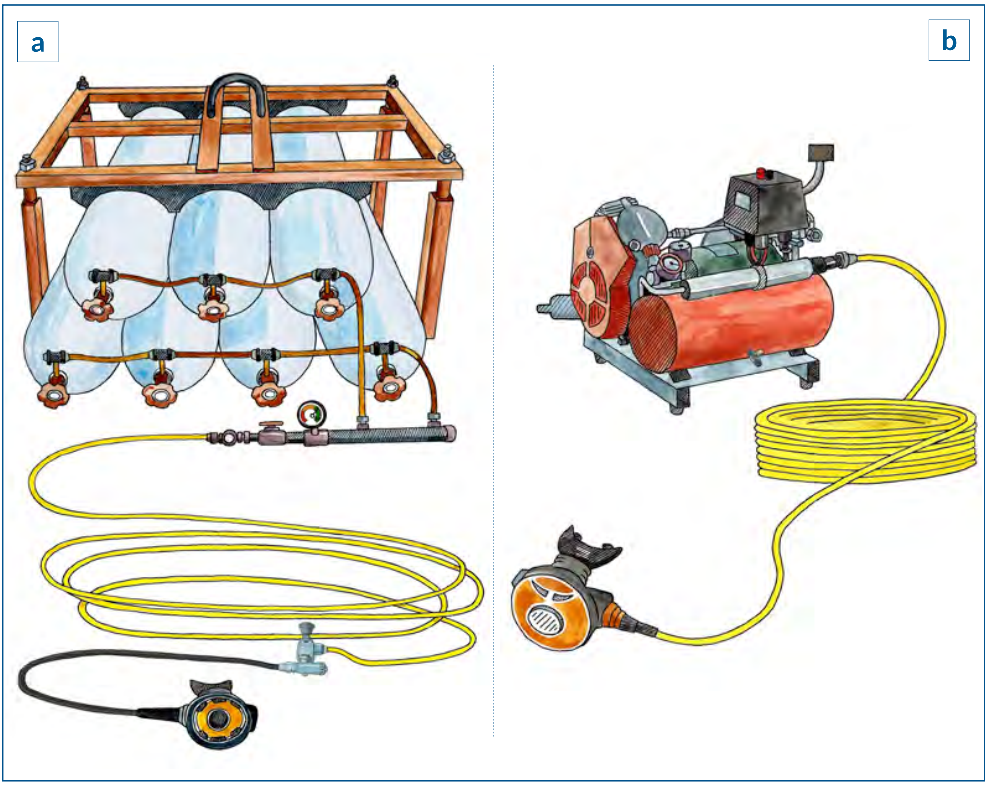


FIGURE 4. A hookah hose connected to a bank of tanks (a) and to a breathable air compressor (b). In (a), the air in the tube is at high pressure (200 atmospheres – atm) and is reduced to 8–10 atm by the first stage of the regulator. In (b), the air is supplied by the compressor at 10 atm and arrives directly at the second stage of the regulator.

When divers use SCUBA, their time underwater is limited depending on the volume of air (number of litres) of air contained in the cylinders and the depth reached.

With hookah systems, the diver's autonomy can be much greater. The duration of the dive must be calculated according to the depth of the dive and the decompression stops required, if any. If possible, decompression dives should be avoided, especially if a hyperbaric chamber is not available in the immediate area.

IMPORTANT

- ► **To avoid headaches, nausea and poisoning that could be caused by breathing poor quality air, the compressed air must be supplied by a compressor that is specifically designed to provide safe air for breathing.**

2.1 Breathing air compressors

The compressors used for diving activities provide high-pressure breathing air from 200 to 350 atm for filling the cylinders, or low pressure (10 atm) for breathing. There are various models with different levels of compression. They have a pumping unit connected by pulleys and belts to a separate electric motor or internal combustion engine. Compressors differ according to the amount of air supplied over time (litres per minute or cubic metres per hour).

The breathing air compressor is a machine that combines the characteristics of an industrial air compressor with filtering and dehumidification systems to remove the water that is produced in significant quantities during compression and that must be drained from the circuit manually (**Figure 5**; **Plate 2**). This is to avoid water, mixed with lubrication oil residues, accumulating in the cylinders, polluting the compressed air and poisoning those who breathe it.

A reservoir tank provides a reserve supply of breathing air and is normally made of non-toxic stainless steel.

Breathing air compressors work in the same way as the compressors used in industry for non-breathable compressed air. There are several cylinders at progressively higher levels of compression, up to a maximum of 350 atm (the pressure at which cylinders are tested), but normally limited to 220 atm.

During the various compression phases, the air passes through condensate separators, which convert the moisture contained in the air into water. This water is then emulsified with particles of oil used in the lubrication of the pumping unit and expelled externally. Before entering the cylinders, the dehumidified air is filtered through activated carbon cartridges, which have to be replaced periodically.

2.2 Hookah apparatus

Hookah systems are suitable for working in shallow water, typically in water less than 20 metres. They consist of an open-circuit breathing apparatus with a long hose, which supplies compressed air to a mouthpiece with a demand regulator; this device is carried by the diver. The air comes from a cylinder or a bank of cylinders located on the support vessel or from a compressor (see **Figure 4**). The diver is therefore free from the weight and bulk of the cylinders, but is connected

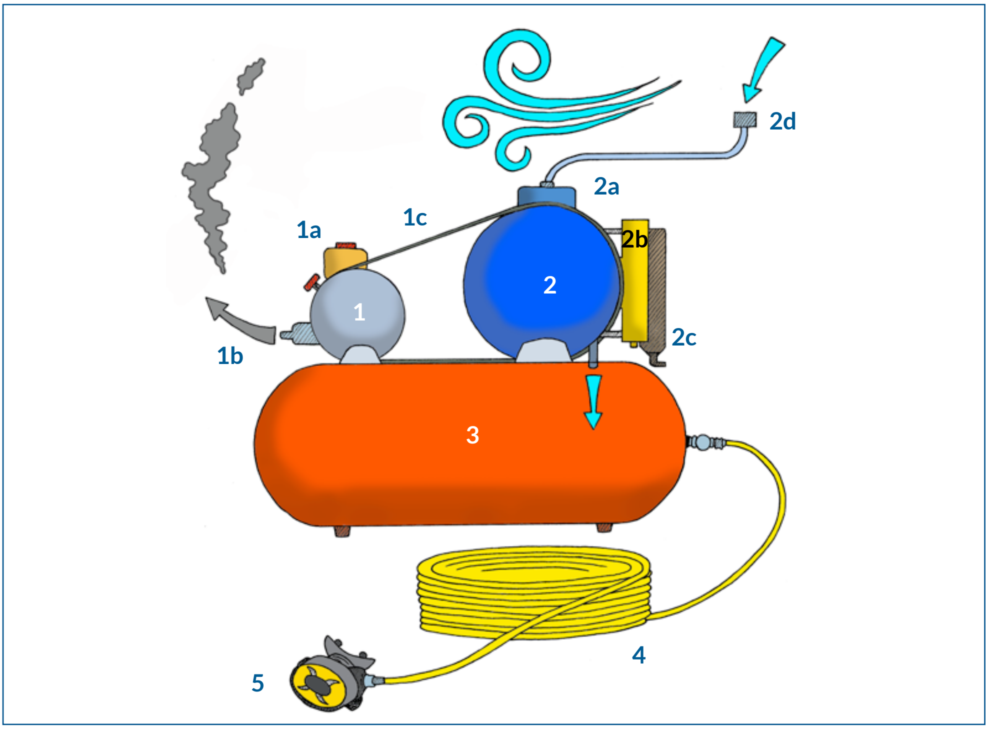


FIGURE 5. Schematic layout of a compressor designed for the provision of breathing air: (1) Internal combustion engine; (1a) fuel tank; (1b) gas exhaust pipe; (1c) drive belt; (2) compressor; (2a) air filter; (2b) active carbon cartridge filter fitted with drain valve; (2c) condensate water tank with drainage valve; (2d) air inlet; (3) compressed air reserve tank; (4) hookah air hose; and (5) dive regulator.

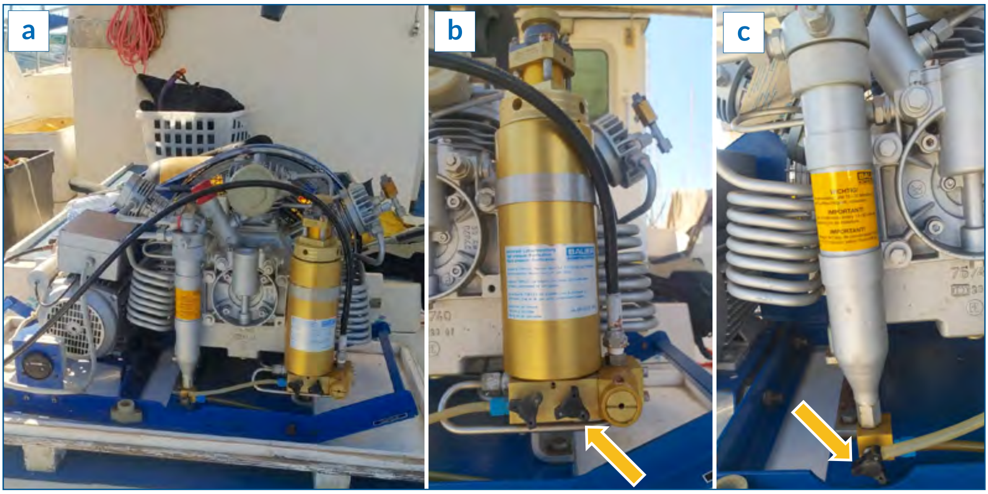
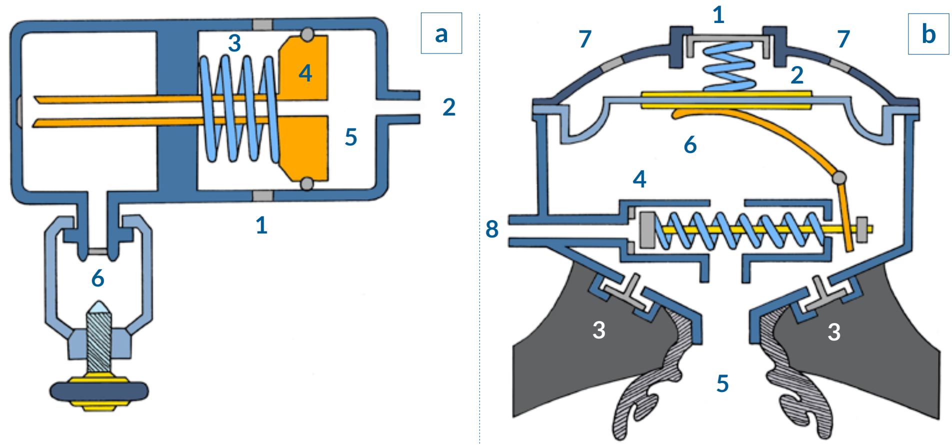


PLATE 2. View of a breathing air compressor for diving: The filter cartridge and the tank for collecting and draining the condensed water are clearly visible (a); details of the active carbon cartridge to filter the intake air, to remove particulates, residual oil and water with bleed openings at the bottom (black screw – see arrow) (b); and tank for collecting and manually draining the condensed water vapour (black screw – see arrow) (c).

to the support vessel by the hookah hose, which is high pressure if cylinders are used, or low pressure if connected to a compressor. The length of this hose restricts the diver’s depth and range.

The mouthpiece and automatic piston or diaphragm regulator can be of two types: one-stage or two-stage (the latter is more widely used). They are fastened by a harness on the diver’s back. The air reaches the regulator first stage at high pressure and then at low pressure to the second stage. From the second stage it is then reduced to ambient pressure. The air is delivered when the diver inhales; this causes downwards pressure in one chamber of the regulator, lowering a diaphragm, which acts on levers that lower a pin. Lowering the pin allows the required amount of air to enter the regulator, which reaches the diver’s mouth (**Figure 6**; **Plate 3**).



FIRST-STAGE (a) DETAILS:
(1) Ambient water pressure; (2) medium pressure air outlet to second stage; (3) high pressure spring; (4) first stage unbalanced piston; (5) intermediate pressure chamber; and (6) high-pressure air from tank.

SECOND-STAGE (b) DETAILS:
(1) Purge button; (2) diaphragm; (3) exhaust valve; (4) downstream valve; (5) mouthpiece; (6) diaphragm pressure chamber; (7) ambient water pressure; (8) air from first stage or medium air pressure from compressor.

FIGURE 6. Regulator scheme – the first stage (a), attached to the tank, reduces the high air pressure from the tank to an intermediate pressure (8–10 atm) before the air flows through the regulator hose to the second stage, which is the part that goes into the mouth of the diver. As the diver inhales, the second stage (b) contains a mechanism that further reduces the intermediate pressure in the hose coming from the first stage to the surrounding water pressure, making it comfortable and easy to breathe. When the diver stops inhaling, the diaphragm relaxes into its original position, releasing the lever that opens the valve that allows air to enter the second stage and hence stopping the airflow.

A one-way valve along the hose, when present, avoids problems if there is a pressure surge caused by the compressor malfunctioning or the hookah hose itself breaking.

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PLATE 3. Dive regulator, (a) first and (b) second stage.

It is good practice for a diver to carry a **small bailout cylinder** (capacity of 5 or 10 litres) with a separate regulator for emergencies in case the compressor breaks and the diver is left without air.

2.3 Dangerous practices

WHAT NOT TO DO – Hookah diving is an underwater activity that has inherent risks. The risks become all the more serious if safety rules are not respected, if divers are physically unfit, or if divers do not have the necessary technical skills or appropriate equipment.

Hookah diving should be carried out only when the diver has proper technical knowledge and equipment.

The following **health hazards** must be strictly avoided.

Physical fitness:

- not having a full medical examination once a year;
- entering the water while suffering from any illnesses and under medication (for example, the use of a medical syrup for treating a flue, coughs and colds);
- drinking alcohol or taking drugs (**Figure 7**); and
- not getting enough sleep.

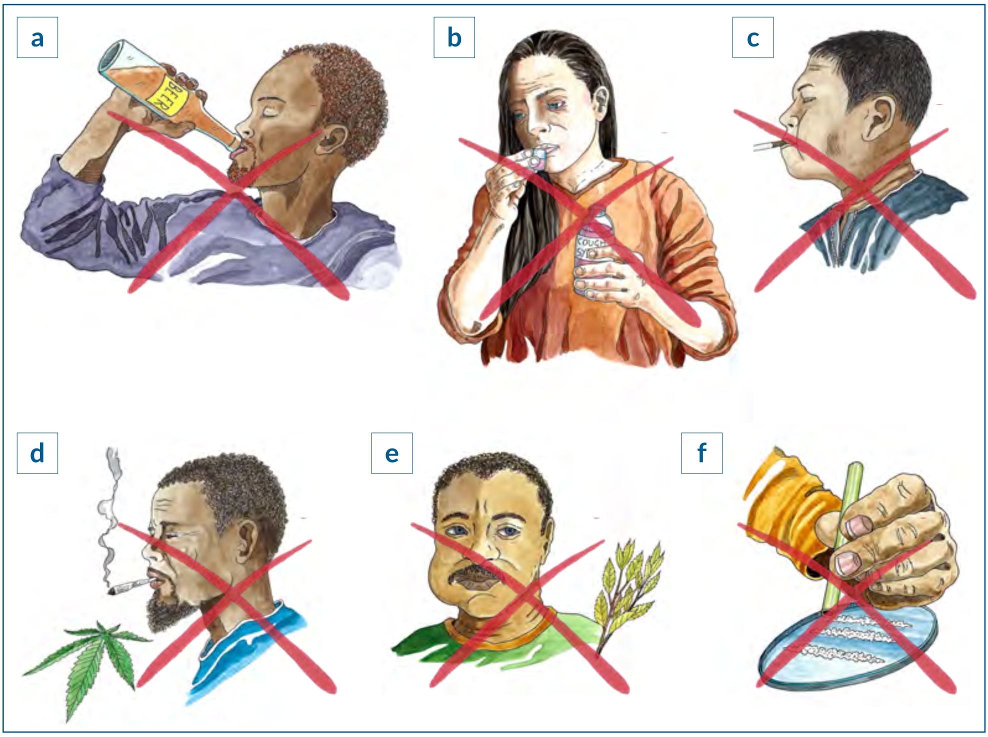

FIGURE 7. The consumption of alcoholic beverages (a), medications (b), smoking (c) and use of soft (d and e) and hard drugs (f) before diving must be strictly avoided.

Technical knowledge:

- not being aware of the basic physical and physiological aspects of diving;
- not knowing the maximum dive times and depths;
- not being aware of the need for decompression stops and not planning them; and
- not knowing how to use the equipment and how to maintain it.

Equipment (see Annex 9):

- diving using air supplied from cylinders that have previously been filled by an industrial compressor or from a compressor not designed for breathing air;
- diving without a depth gauge and watch – unless the diver already knows the depth of the area and has agreed on the signals with the assistant on the support vessel to communicate the length of time on the seabed using the lifeline. In this case, the decompression stop times need to be marked on the ascent/descent anchored line at the right depths. This must be prepared in advance (see **Figure 3**);

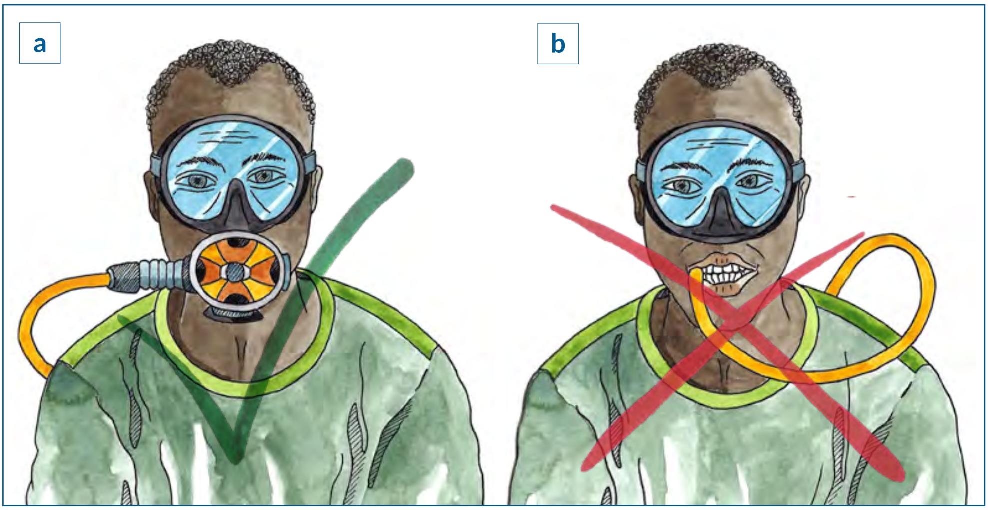

FIGURE 8. Diver with (a) and without (b) a diving regulator (very dangerous!). Diving without a regulator will not permit the diver to breathe comfortably and at regular and control intervals, as needed, at the air pressure corresponding to the corresponding depth.

- not having an efficient, well-maintained one-stage or two-stage regulator and breathing directly from the hookah hose (**Figure 8**) (see **Annex 10**);
- not having a wetsuit of the right size and thickness to protect the diver from the cold and to avoid compressing the chest and limbs;
- not having a dive knife;
- not carrying enough diving weights to achieve slight positive buoyancy on the surface and stability on the seabed. The diver should wear them on a weight belt with a quick-release system so they can be removed instantly in an emergency; and
- not being connected to the vessel with a lifeline of at least 35 metres long to which the hookah hose is attached, leaving some slack (see **Figure 22**). The lifeline is the means of communication between the seabed and the support vessel using agreed signals (including emergency signals), and it is also used to guide the diver back to the vessel. The hookah hose should never be used for signals nor to retrieve the diver. **The diver should never pull the hookah hose to ascend, as the hose is not made to carry loads** (**Figure 9**).

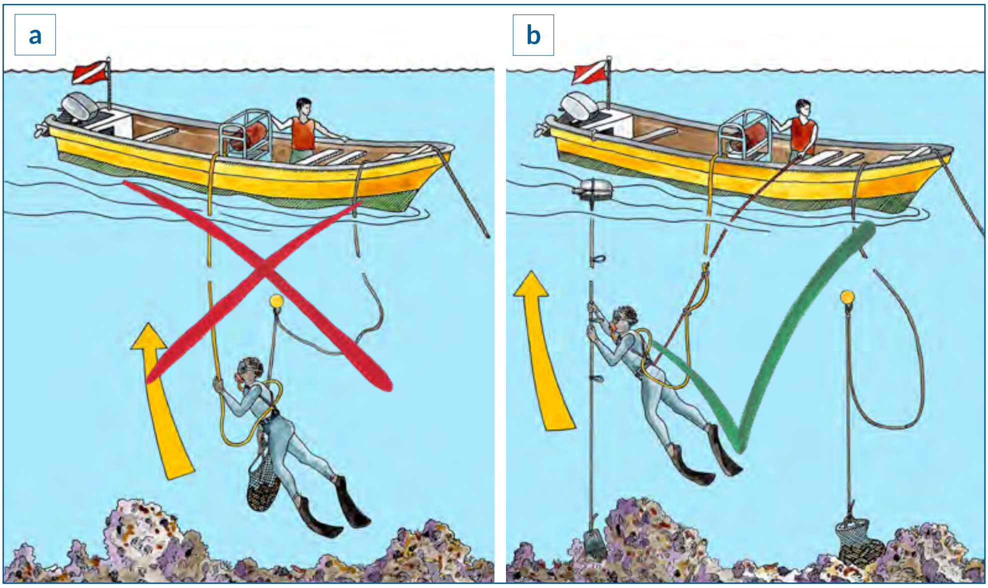

FIGURE 9. Diver ascending on hookah hose (wrong!) (a). The tube is not made to withstand weights and tension. In addition, the diver must ascend slowly, vertically, and eventually be able to stop for the decompression stops. Surfacing should be via the appropriate vertically positioned line fitted with handles at the depth of the decompression stops (9, 6 and 3 metres) (b).

Operational procedures:

- descending to the seabed rapidly (faster than 24 metres per minute), by uncontrolled descent ("freefall");
- using a hookah system below a depth of 21 metres;
- not performing middle ear equalization and continuing descent regardless of severe ear and sinus pain;
- working excessively or strenuously on the seabed making the diver breathless;
- not checking the dive time and depth (unless the support vessel is checking these and sending signals);
- ascending too rapidly (faster than 9 metres per minute or faster than the air bubbles exhaled by the diver);
- holding breath while ascending, which traps air in the lungs;
- not carrying out decompression stops at the right depths and for the right amount of time, which are indicated in the dive tables (see Annexes 4–7), if needed;

- not stopping the dive in the event of nausea, headache, pain or excessive cold conditions;
- carrying out more than two dives in one day;
- diving for more than three days in a row;
- not agreeing on the communication signals with the assistant on the support vessel before starting the dive;
- resurfacing and returning to the seabed several times during the dive; and
- not checking for the possible presence, and behaviour, of marine species that are potentially dangerous to humans (sharks, stingrays, eels, venomous fish and fire corals, for example).

3. Going underwater while breathing compressed air

Going underwater while breathing compressed air may seem easier than freediving, but this method can have dangerous effects on the human body.

3.1 The ear and facial sinuses

As the depth increases so does the difference in pressure between the outer ear and the middle ear, which communicates with the mouth through the Eustachian tubes. This occurs just a few metres underwater. The eardrum between the outer and middle ear bends inwards as external pressure increases, causing pain, which intensifies until air is introduced into the middle ear through the Eustachian tubes. This act is called equalization. It is done by pinching your nose with your fingers and slightly increasing the air pressure in the nose, like carefully blowing your nose, or simply by swallowing. If the tubes are free, air passes through easily and there is no more pressure difference. The shape of the eardrum returns to normal and the pain stop (**Figure 10**).

If the tubes are not free, air does not pass. As the diver continues to descend, the pain becomes more and more intense until the eardrum ruptures. This causes bleeding and water to enter the middle ear, possibly also causing loss of balance.

If equalization fails, it is important to stop descending and to ascend until the pain stops before descending again and repeating equalization until it succeeds.

As well as being very painful, a ruptured eardrum can cause permanent damage to hearing, impairs sense of balance and leads to serious infections.

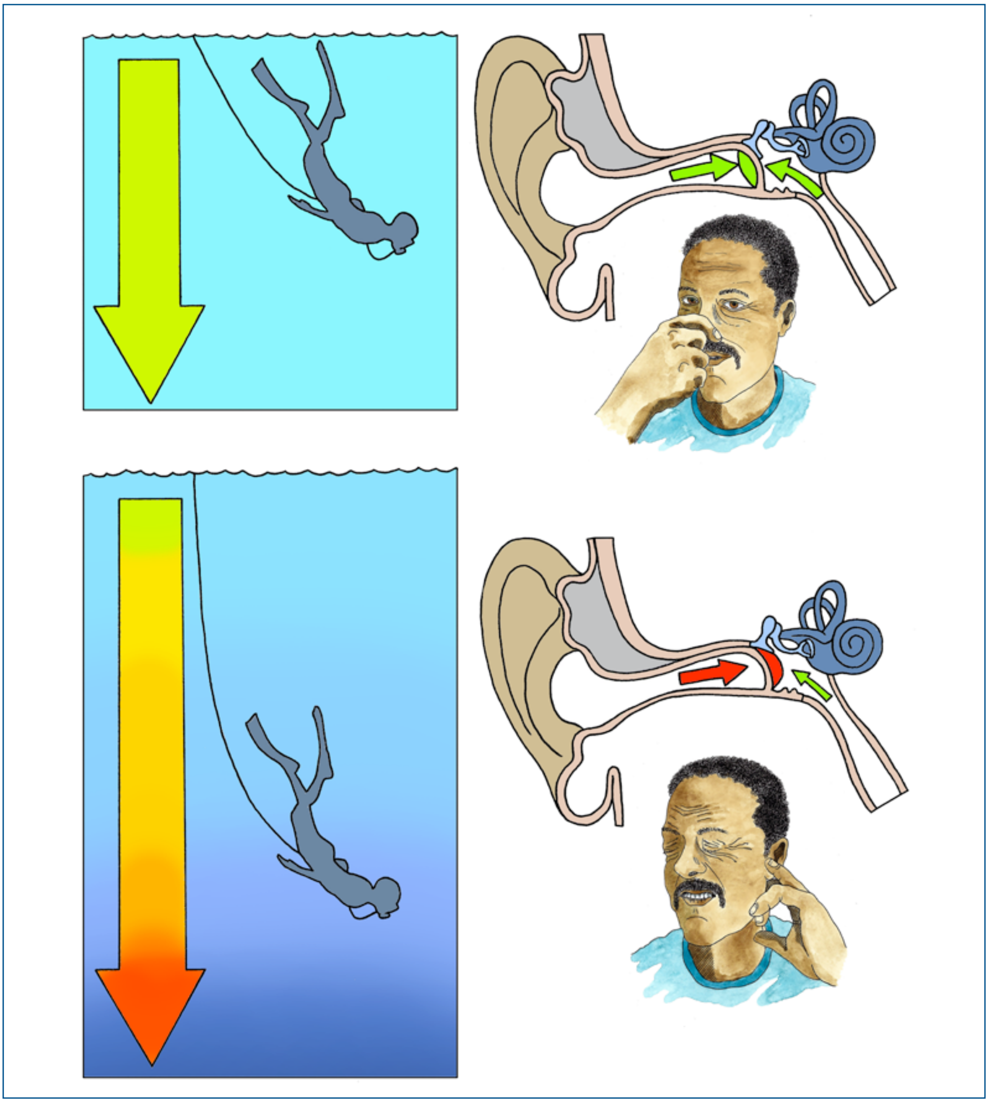

FIGURE 10. Effect of the external pressure on the eardrum. In case of slow and difficult ear pressure equalization followed by increasing pain, the diver should ascend to the point that no pain is experienced (or relief depth) and start the descent again. A diver who fails to equalize pressure in the eardrum should not force equalization and give up the dive.

During descent, a diver should stop the dive if feeling a sharp pain in the forehead or under the cheekbones, places where the frontal and maxillary sinuses are located (**Figure 11**). Pressure in these air-filled cavities also needs to be balanced with the air that a diver breathes in. If the ducts that connect them with the nasal cavity become obstructed, preventing equalization, the result is severe pain.

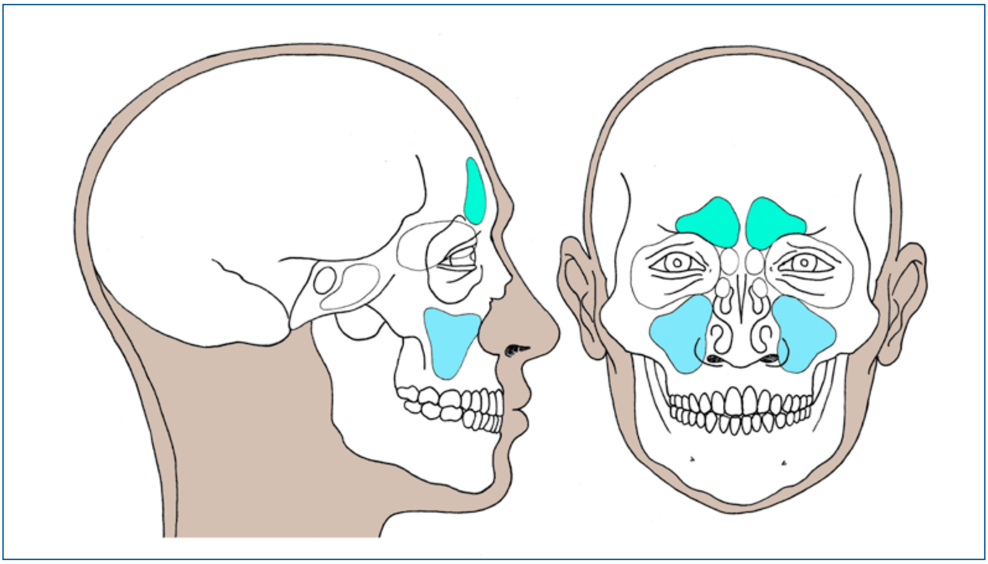

FIGURE 11. Facial sinuses. The main facial sinuses (frontal and maxillary) are cavities which, like the middle ear, must equalize the internal pressure with that of the external environment, with the passage of air through thin channels that put the sinuses in communication with the nose. When these channels become blocked, the air does not pass and during the descent towards the bottom the pressure cannot be equalized and acute pain arises. The only remedy is for the diver to return to the relief depth and try again. If the block persists, the diver should return to the surface and stop diving.

3.2 Breathing

Breathing supplies oxygen to all body tissues. Breathing also expels waste products from the activity carried out by the cells, which is mainly carbon dioxide (CO_2).

Air consists of nitrogen (79 percent), oxygen (20 percent), carbon dioxide (0.04 percent) and small amounts of other gases (0.96 percent).

During normal breathing, 4 percent of the oxygen contained in the air is used by the human body for cellular functions. This produces carbon dioxide (and water), which is the waste product of metabolism in the body. In the air exhaled, there is therefore always 79 percent nitrogen, 16 percent oxygen, 4.04 percent carbon dioxide and 0.96 percent other gases. Each breath burns 4 percent of oxygen and returns 4 percent more carbon dioxide.

A healthy, fit, well-trained diver breathes an average of 6 litres of air per minute. This must be multiplied by the pressure at which the diver is breathing: 6 litres per minute at the surface (1 atm) will become 12 litres per minute at a depth of 10 metres (2 atm), and 18 litres per minute at a depth of 20 metres (3 atm), while lung ventilation remains constant in volume. These variations must be accounted for meticulously when calculating the amount of air needed for a hookah/SCUBA dive, always providing extra air as a precaution in case the diver needs to cope with unforeseen events (for example, an increase in the breathing rate due to fatigue, stress and coldness) (see Section 4.1).

Throughout a dive, the diver should strive to maintain a constant breathing rate to avoid becoming breathless through excessive exertion. If this happens unexpectedly, the diver should pause until normal breathing resumes. Shortness of breath (sometimes called air hunger) is caused by the body's tissues demanding more oxygen, and irregular breathing with exhalations that are too short can lead to a dangerous increase in carbon dioxide in the blood. If the carbon dioxide rises above a certain limit, the diver can faint.

3.3 Compressed air and the blood

At the surface (1 atm), the fluids and tissues in the human body are balanced with the gases in the air we breathe. Nitrogen makes up 79 percent of air, so the partial pressure of nitrogen in both the air we breathe and in the blood is about 0.8 atm when at the surface. When a diver descends to a depth of 10 metres, the air is at twice the pressure, so the partial pressure of the nitrogen is $0.8 \times 2 = 1.6$ atm in the air the diver breathes, while in the blood there will still be a partial pressure of 0.8 atm.

As gas tries to reach a balance, nitrogen will pass from the air into the blood, dissolving in the blood as a liquid (**Figure 12**). The same process will then take place in the rest of the body between the blood and the various tissues. This happens at different rates depending on the difference in pressure between the blood and the different body tissues. It also depends on the amount of blood flowing through the tissues and on how much nitrogen each tissue can hold until the whole body has absorbed enough to achieve the same partial pressure as the air that is breathed in. This is called tissue saturation.

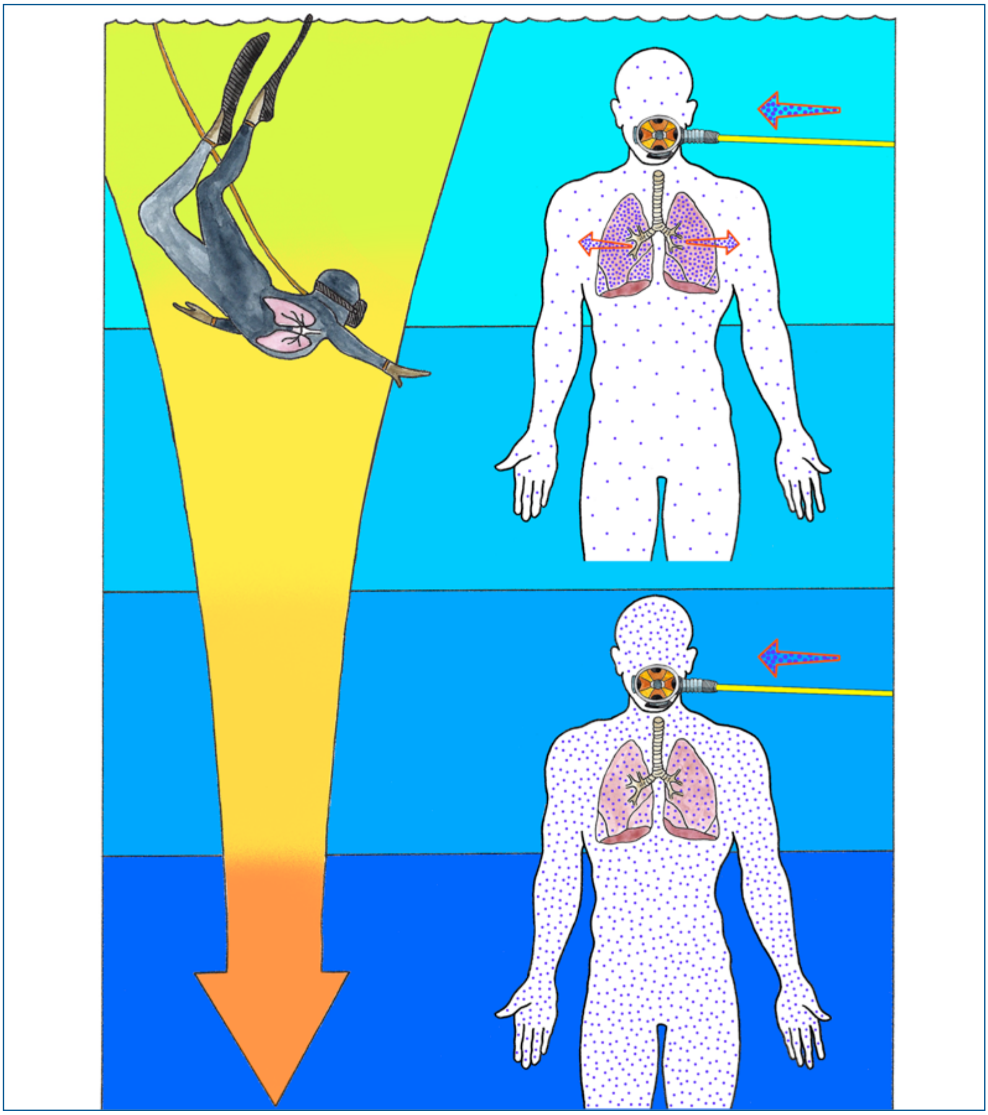

FIGURE 12. LUNGS-BODY GAS PASSAGE DURING COMPRESSION: While divers breathe compressed air when descending to the bottom, the nitrogen pressure will increase in the lungs (see top figure), while in the blood and body tissues the nitrogen will still be at the pressure it had while at the surface. Because of the difference in pressure, the nitrogen in the lungs changes from a gaseous to a liquid state and moves into the blood and body tissues until the partial pressure (tension) will be equal between lungs, blood and body tissues (see bottom figure).

3.4 Compression and decompression

During compression (descent from the surface to the seabed) and while the diver is on the seabed, nitrogen continues to dissolve from the air that is in the lungs to the blood and from the blood to the tissues until the partial pressure in the tissues equals the partial pressure in the air which the diver breathes. The longer the diver spends at depth, the more nitrogen will be absorbed by the body. When the diver ascends, the process is reversed – called decompression. All of this additional nitrogen needs to be released from the body by passing from a liquid to a gas and then exhaled by the lungs (**Figure 13**).

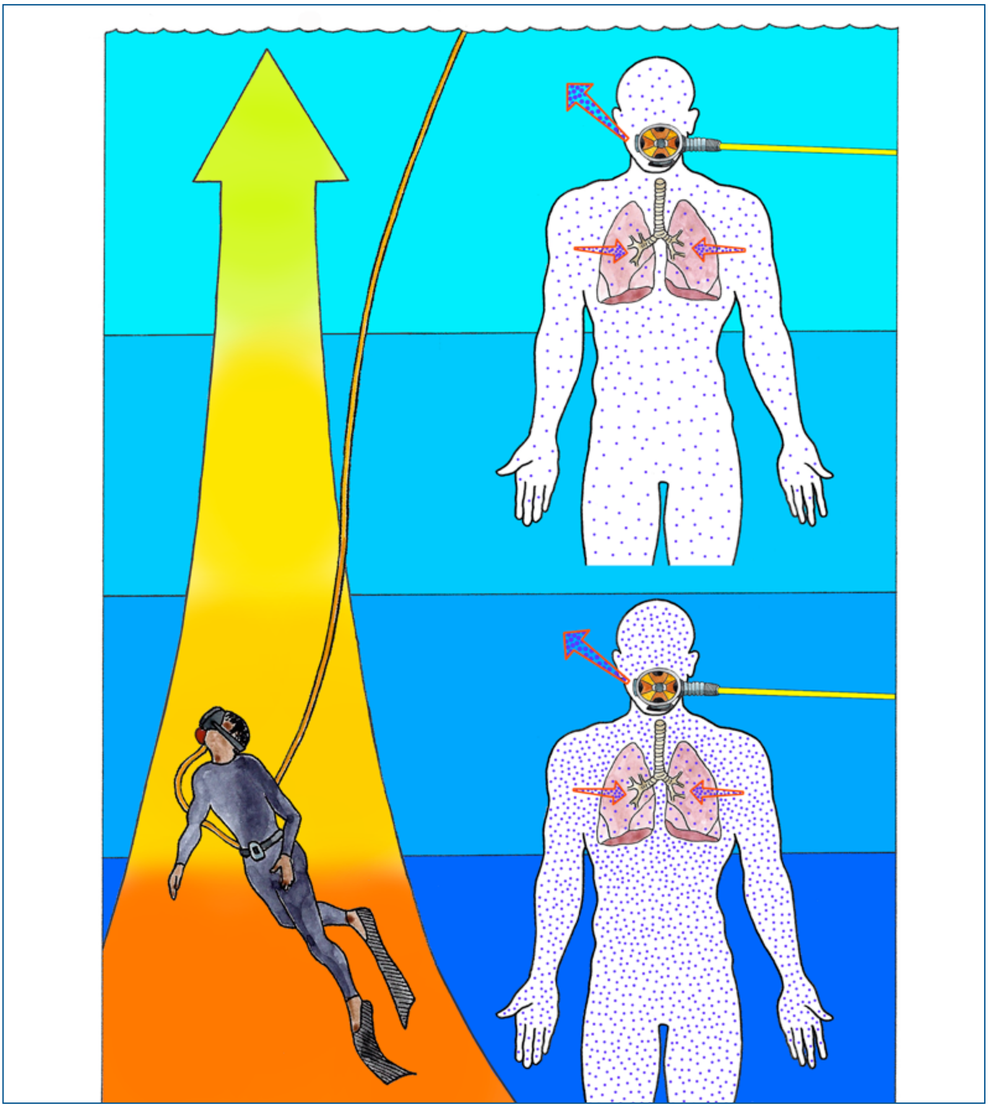

FIGURE 13. BODY-LUNGS GAS PASSAGE DURING DECOMPRESSION: After a given time spent on the sea bottom, the partial pressure (tension) of the nitrogen will have increased in the blood and body tissues; ascending towards the surface the diver will breathe air (with nitrogen) at a lower pressure than that on the bottom. A new pressure difference will then occur, but inverse to that during the descent: greater in the blood and less in the lungs. The nitrogen will then return from the liquid to the gaseous state to the lungs and will be expelled through breathing. Upon arrival at the surface, there will still be a pressure of residual nitrogen from the dive in the body, which will continue for some hours to pass from the tissues to the blood and from here to the lungs to be expelled through breathing.

During decompression, the time it takes for nitrogen to be released depends on the amount of nitrogen accumulated in the different tissues and the difference in pressure between these tissues and the blood. The higher the pressure, the more forcefully it will try to "push" into the blood.

Complete desaturation, meaning the removal of all the nitrogen, may take 12 hours or more.

If the diver ascends into water too fast, bubbles of nitrogen will form in the blood and tissue. This is similar to when a soft drink is shaken while still in the bottle, and then the bottle is opened suddenly – but this process instead happens inside the organs of the body. The formation of bubbles of nitrogen in the blood and tissues and its effects is called decompression sickness, Caisson disease, or the "bends" – a serious and sometimes fatal condition (**Figure 14**).

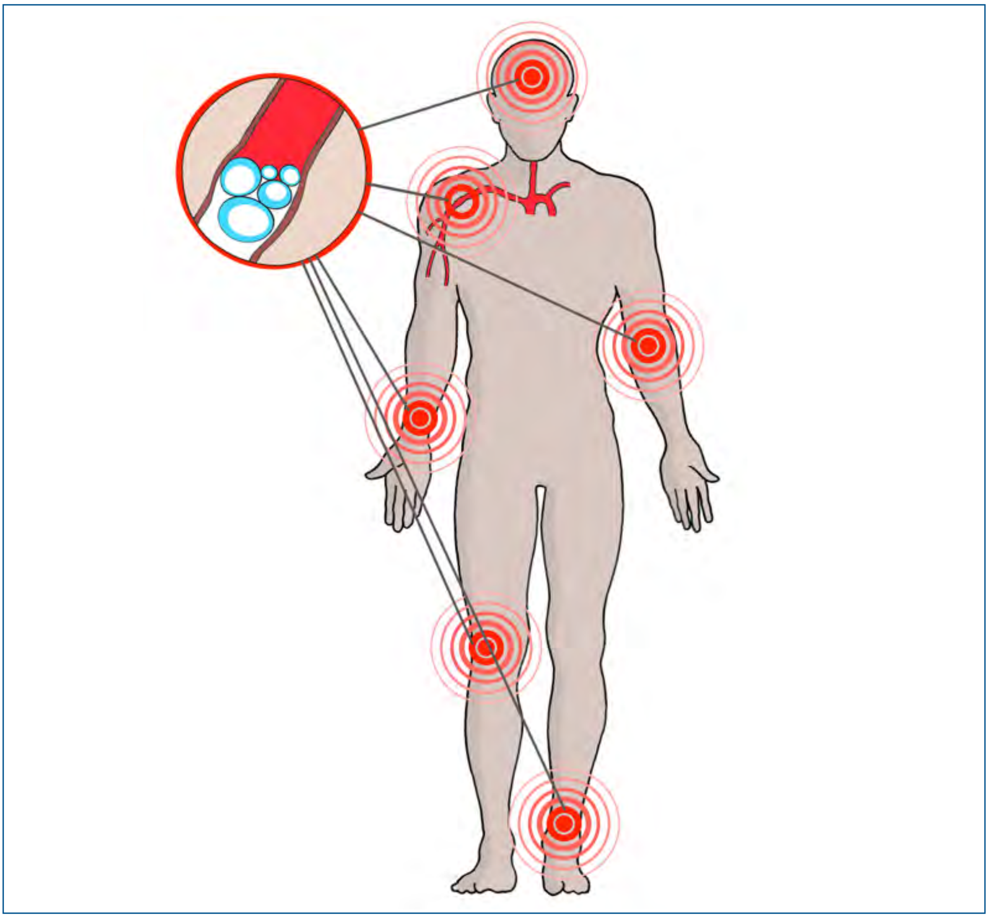

FIGURE 14. Decompression sickness. If the nitrogen accumulated in the body tissues during the dive has had no time to return slowly to the gaseous state into the lungs (because of incorrect decompression stops), it passes in the gaseous state directly into the blood, forming bubbles. These bubbles can block blood vessels and circulation and, depending on their location in the body, cause paralysis of the limbs with pain and other more or less severe symptoms.

3.5 Decompression tables

To avoid decompression sickness, the dissolved nitrogen must be released from the blood slowly. Decompression tables (also known as dive planners) provide precise instructions on how long the diver needs to stop and at what depths to allow the release of nitrogen without the formation of bubbles in the blood or tissues. Decompression tables depend on the depth the diver reached and the time spent there.

A fit and well-trained diver who makes a good note of the depths and times of the dive can normally avoid decompression sickness by following the decompression tables. However, sometimes compliance with the tables does not prevent decompression sickness because of other conditions, such as fatigue while underwater, stress, coldness, age and obesity.

The tables (in Annex 4) show the total time (descent time plus time on the seabed) for each maximum depth reached. For each total time, there are indicated the depth and number of minutes of every stop the diver must make while ascending.

The speed of descent (maximum 24 metres per minute) and of ascent (maximum 9 metres per minute) must be respected. A good practice is to ascend slower than the smallest bubbles you breathe out into the water.

WARNING

1. If the depth and duration of the dive are not indicated in the decompression table, always round up to the values higher up in the table.
2. Likewise, even when the depth and duration of the dive are indicated precisely in the table, if the activities on the seabed are particularly strenuous, if the water is cold or if there are other stress factors that alter the breathing rate, **the diver must consider a higher time or depth values, or both. For example, if the dive takes place at a depth of 15 metres for 120 minutes but the work was strenuous, the diver applies the decompression table information for a dive of 130 minutes at a depth of 18 metres.**
3. When calculating the total bottom time (descent time plus time spent on the seabed), the maximum depth reached should be considered, even if very little time is spent at this depth compared to the total dive time.
4. **When the diver is familiar with the seabed and knows the depths to be reached in advance, it is good practice to start at the deepest depth and then move up to shallower depths.**

3.6 No decompression dives

The table below shows that for certain maximum times at the various depths indicated no decompression stops are needed, not even a stop at a depth of 3 metres. Specifically:

Depth (metres)	Time spent on the seabed (minutes)	Stop at 3 metres underwater (minutes)
10.5	310	0 (5)
12	200	0 (5)
15	100	0 (5)
18	60	0 (5)
21	50	0 (5)
24	40	0 (5)
27	30	0 (5)
30	25	0 (5)

Source: US Navy air decompression tables and recompression chamber operator´s handbook. Revision September 1995. Best Publishing Company.

The information in the table above reveals that no decompression is necessary if the diver does not reach a depth of 10.5 metres. For greater depths, decompression is only required if the dive lasts longer than the maximum times indicated in the table.

RECOMMENDED

- **As a precaution, before resurfacing it is strongly recommended that the diver stops for 5 minutes at a depth of 3 metres, even after a dive which in theory does not require a decompression stop.**

3.7 Repetitive dives

WARNING

- **Resurfacing after observing the decompression tables does not mean that the body has freed itself of all the nitrogen that was absorbed by the blood and body tissues. It means that the quantity of residual nitrogen still in the tissues and the difference in pressure between this and the air in the lungs are tolerable and will not cause gas embolism (the exception is when other factors play a role, such as the diver’s age, fatigue, lack of sleep, obesity, alcohol abuse, various ailments and water coldness).**

If the diver re-enters the water before having completely eliminated the nitrogen absorbed during the previous dive, this residual nitrogen in the blood and body tissues must be considered and added to the next dive.

To avoid this problem and eliminate the residual nitrogen absorbed, the diver should allow a 12-hour surface interval between the first and the second dive. This becomes 24 hours if the first dive is particularly long, specifically:

- More than 300 minutes at a depth of 12 metres/40 feet
- More than 240 minutes at a depth of 15 metres/50 feet
- More than 200 minutes at a depth of 18 metres/60 feet
- More than 170 minutes at a depth of 21 metres/70 feet
- More than 150 minutes at a depth of 24 metres/80 feet
- More than 130 minutes at a depth of 27 metres/90 feet
- More than 120 minutes at a depth of 30 metres/100 feet

When the duration of the first dive (descent time plus bottom time) is normal (in other words, below the dive times indicated above at the given depths) and the diver cannot wait for at least 12 hours before making a subsequent dive, the following measures can be taken into consideration:

(i) If the next dive is to a depth that does not exceed 10 metres, then no additional precautions are needed.

(ii) If the next dive is deeper than 10 metres, and the time interval between the end of the first dive and the beginning of the second dive is less than 10 minutes, the time of the first dive is added to that of the second at the maximum depth reached. It should be regarded as one single dive, just omitting the ascent and decompression time from the first dive.

(iii) If the next dive is deeper than 10 metres, and it happens more than 10 minutes later, consider the following:

- either the method in point (ii) is applied

  or

- the dive tables for subsequent dives are used as follows:

  (a) In the decompression table (Annex 4), the last column on the right contains letters for each dive length at different depths; these are symbols to be used to calculate subsequent dives. The same symbols are also contained in another table (Annex 5) for the length of dives at different depths, which do not require decompression stops.

WARNING: When added together, two dives that do not require decompression stops may constitute one dive requiring decompression stops (see **Figure 21**).

(b) A third table (Annex 6) deals with the release of nitrogen from the body between the end of the first dive and the start of the next. This interval must be longer than 10 minutes in order not to fall under case (ii), above. In this table, the letters (symbols) regarding the "exit" from the first dive change according to the time spent on the surface. At the time of entering the water for a subsequent dive, therefore, there will be a new "entry" letter to be obtained from the table.

(c) Lastly, in Annex 7 (residual nitrogen time) based on the new "entry" letter, the time to be added to the time of the next dive is indicated (thus obtaining the equivalent time of a single dive) depending on the depth of the second dive. This serves to ensure that decompression on the second dive also takes into account the residual nitrogen from the first dive. If the exact depth value for the next dive is not shown in the table, the one for the next lower depth should be used (for example, if it is -17 metres, use -15 metres and not -18 metres).

(d) In the event of further dives – which are strongly discouraged – the same procedure is repeated, taking into consideration the equivalent time of a single dive, as if it were that of a first dive.

WARNING

- **Diving for more than three consecutive days is not advisable and is strongly discouraged.**

3.8 Decompression sickness

Decompression sickness may happen when errors in calculation occur or when there is a sudden ascent to the surface. Under these circumstances, it is vital that a diver remain calm and make decisions rapidly. Quick measures may save the diver from serious injury or death.

At the first signs of illness, such as joint pain, headache, nausea or impaired vision, the diver must stop all activities immediately and report the emergency to the assistant through the lifeline. In shallow water, if physically able, the diver should descend to a depth that provides relief from the symptoms (never deeper than 30 metres) before ascending to the correct depths to make the following decompression stops shown in this table, increasing the time at the depths of 9, 6 and 3 metres if the stops that had previously been planned were longer.

Depth (metres)	Duration of stop (minutes)
30	5
20	15
9	20
6	30
3	50

Source: Moretti, G.C. 1968. La sicurezza per i sub. I libri della lanterna. Palermo, Vito Blanco editore.

If symptoms occur after resurfacing, the diver and the assistant must decide quickly whether to attempt to reach a recompression chamber (also called hyperbaric chamber) or to proceed with emergency recompression in the water as indicated in the table above. When deciding, the diver and the assistant need to consider that the faster recompression therapy takes place following the onset of symptoms the greater the chances of success.

When the diver and the assistant are assessing the practicability of this latter option (recompression at sea), they must evaluate the following factors in the situation:

- the feasibility of supplying air from the support vessel for the entire duration of the treatment;
- the physical and mental state of the diver (for example, pain, paralysis, coldness, seizures, shock);
- suitable, stable weather conditions, with no strong currents or wind; and
- the availability of another diver, preferably with SCUBA equipment (this avoids using two hookah systems from the same vessel), to assist the injured diver and who can communicate with the surface.

It is important to get to a recompression chamber if symptoms persist once the diver has surfaced.

WARNING

- **Emergency recompression in the water is a risky procedure and should be considered only in extreme emergency cases. A recompression dive should be done with the assistance of a trained diver, or preferably a hyperbaric medic if available.**

4 Operations with hookah apparatus

Hookah systems have the advantage of not burdening the diver with the weight and bulk of a breathing apparatus. This means that the dive can last longer because the support vessel can carry larger quantities of air tanks or a compressor on-board.

Longer dive times mean that the diver needs to calculate nitrogen saturation and the need for decompression, as well as negative factors such as the effects of fatigue and cold. In addition, being connected to the support vessel and dependent on it for air makes the vessel-diver system one single operational unit.

The diver is inextricably linked to the support vessel and is dependent on it to breathe. The area of the seabed where the diver can move is limited by the length of the hookah hose and the lifeline to which the hose must be secured (also called the diver's umbilical). In turn, the vessel must be careful not to tug the diver if it moves (moving the vessel is strongly discouraged) as the diver searches the area and harvests sea cucumbers or other organisms.

Additionally, organizing the dive, based on who has the essential pieces of equipment – the watch and the depth gauge – is necessary. The key phases of the dive need to be managed and monitored by the person who controls the time, whether that is the diver or the assistant.

When divers have the watch and the depth gauge, they can monitor their own dives, checked by the assistants. When the assistants have the watch, they will supervise the dives using prearranged signals on the lifeline. If the diver does not have a depth gauge or if it malfunctions, a manual plumb line can be used, which is a rope or line with a weight at one end. In this case, the assistant on-board must be in charge.

If, on the other hand, a watch is not available, the dive should not be attempted, or it can only be attempted up to a maximum depth of 9.1 metres. Below this depth, a decompression stop may be necessary after a certain amount of time when the dive cannot be measured. A precautionary decompression stop would then be roughly calculated for 5 minutes at a depth of 3 metres. Clearly, this is extremely unwise, and such circumstances should be forbidden by the company and by any supervisory authority. The diver should also refuse for safety's sake.

The diver and the assistant must have the same level of technical knowledge, understand each other, and communicate by exchanging signals using the lifeline. While working, they must each constantly think about what the other one needs or is doing. Together, they must plan the dive and decide what to do in an emergency.

Activities that take place in a confined space when the vessel is small include managing the equipment in the vessel, passing the long hose to the diver who gradually moves away from the vessel, deploying the hose and bringing it back on-board, retrieving the diver and the product, and managing the compressor. This requires good organization and teamwork by the operators.

The next section details useful tips for working with a hookah diving system safely.

4.1 Diver and team equipment

Working with hookah equipment means that the support vessel must continuously supply the diver with breathable air for the entire duration of the dive, at a pressure that is sufficient to reach the planned depth. To achieve this, it is necessary to have either a bank of high-pressure cylinders that were previously filled on land or a breathing air compressor. The latter needs a pumping unit equipped with activated carbon filters and a device to discharge the condensation that forms in the air during compression (see **Figure 5**).

The pumping unit works when connected to the engine, which can be electric powered or internal combustion. If the motor is electric, the compressor can only be used on land to fill a bank of cylinders, which, once filled, can be connected to the regulator supply hose.

It is then easy to calculate the amount of air needed, because a healthy, physically fit diver breathes compressed air at an average rate of 6 litres per minute multiplied by the pressure at the diver's depth. For example:

A dive that lasts 3 hours (180 minutes) at a depth of 21 metres (3.1 atm) will therefore require:

6 litres × 180 minutes × 3.1 atm = 3 348 litres of air

Considering that breathing air compressors normally fill at 200 atm, two 10-litre cylinders provide a reserve of 4 000 litres of air (20 litres × 200 atm), which is therefore sufficient for the dive time and depth used in the example above. However, if the diver is poorly trained and/or working under physically demanding and strenuous conditions, the air supply should be doubled from a security point of view.

WARNING

- **Cylinders must be tested every 2–5 years. A rusty or damaged cylinder can explode while being filled, or if dropped or struck, bursting with the devastating force of a bomb.**

The best and safest system for providing air to the hookah regulator is to use a bank of cylinders on-board the support vessel. It ensures that a sufficient quantity of air is delivered at the right pressure. It does not take up much space on-board, there is no need to check it in the same way as an on-board compressor, and above all, there is no danger that the air supply can be interrupted during the dive due to a malfunction.

Using cylinders is therefore preferable to using an on-board compressor, which must have specific characteristics to supply breathable air, such as a combustion engine connected to a compressor with its air intake positioned high up and upwind of the exhaust outlet; a condensate separator and filter; minimum power of 5 hp; a 60-litre storage/bailout reservoir; and minimum pressure on delivery of 10 atm.

Even with these key features, it should be observed that delivering air to the diver using a compressor means that the compressor must be constantly monitored, condensate needs to be drained, sufficient fuel is required for the engine on-board, and the position of the air intake with respect to the engine exhaust outlet needs monitoring, which must always be downwind to avoid exhaust fumes entering the breathing system (**Figure 15**). Furthermore, if there is a breakdown, there would only be a reserve supply of 600 litres of air (60 litres × 10 atm), which may not be sufficient for decompression or in an emergency.

Also, as an additional safety precaution in case the compressor breaks down, one air tank fitted with a regulator could be suspended at -6 metres under the boat.

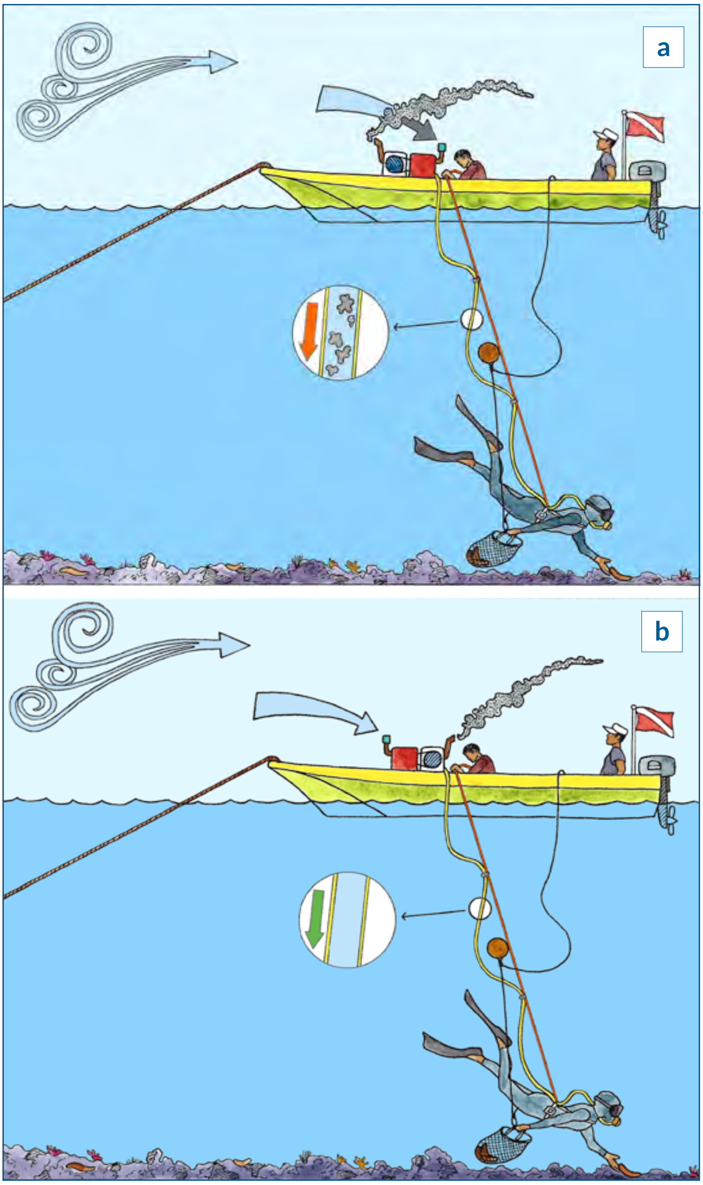

FIGURE 15. Compressor air inlet with engine exhaust downwind. If engine exhaust gases enter the compressor's air intake, it will be breathed in by the diver, causing intoxication (a). The correct position of the air inlet should always be positioned upwind with respect to the engine exhaust pipe as in (b).

Makeshift solutions must be avoided. For example, compressors designed to supply industrial air (**Plate 4**) should not be used for diving because they do not supply breathable air, are not fitted with filters or a condensate drainage tap, do not have suitable and sufficient low pressure reserve tanks, and oftentimes electric motors that are replaced with internal combustion engines can be unreliable and often poorly maintained. This type of equipment should never be used for diving. The use of this type of compressor is the cause of many diving accidents. These compressors are prone to technical breakdowns – a failure to deliver air can cause drowning – and can poison divers due to the poor quality of the air supplied.

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PLATE 4. Example of a modified industrial compressor not suitable for supplying breathable air to divers (very dangerous). With such a compressor, the condensed water cannot be drained and it provides no air filtration system and hence results in the likely intake by the diver of toxic particles from the engine exhaust fumes.

The hookah air supply hose must be suitable – able to withstand pressure of at least 15 atm if a compressor is used or 250 atm when using high-pressure cylinders on-board. The hose must be inspected regularly and replaced when there is any wear, cuts or cracks in the rubber. **The hose must always be loose in the water and never subjected to direct pulling forces**. It must be attached to the lifeline that connects the diver to the assistant in order to exchange the agreed signals.

The regulator must be secured by a harness on the diver's back (if single stage, or the first stage of a two-stage regulator when using cylinders), and also requires proper maintenance.

WARNING

- **A two-stage regulator (in which the first stage reduces cylinder pressure from 150–200 atm to 8–10 atm) is essential if the air comes from a high-pressure bank of cylinders. A hose that is connected directly to the second stage is only possible when a compressor is used and when it is supplied in this way by the manufacturer. Do-it-yourself connections are not recommended, as they can cause serious problems if they malfunction during a dive (Plate 5).**

PLATE 5. Diver with a do-it-yourself connection between the regulator and the hookah air hose (dangerous! see red circle). In the event the two detach from each other, the diver will suddenly run out of air. Furthermore, fastening the air hose around the diver's waist can crush the hose and reduce the air flow.

The air hose coming from the compressor and connected directly to the second stage of the regulator must be firstly safely secured on the diver itself. Knotting the air hose around the diver's body should be absolutely avoided to avoid damaging the tube, blocking the airflow and ultimately distressing the diver (**Figure 16**).

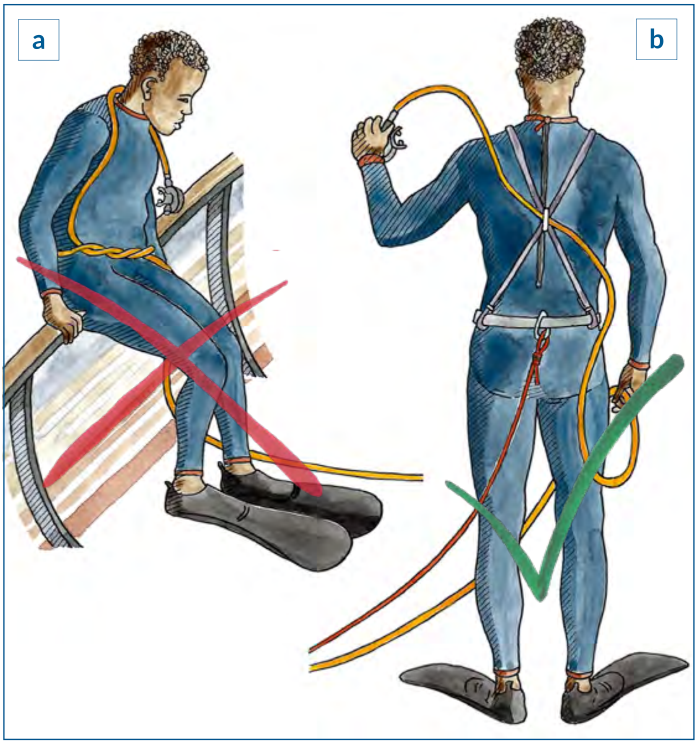


FIGURE 16. The hookah air hose should not be tight around the waist of the diver (a) but secured on the back of the diver as illustrated (b).

In addition to the hookah apparatus, the diver must be equipped with a wetsuit, fins, a mask, a snorkel for breathing on the surface, a knife, dive weights on a belt with a quick-release system, an underwater torch, a watch, and a depth gauge. The availability of a bailout cylinder (including a separate regulator) would increase safety in an emergency.

If the same equipment is used by more than one diver, especially regulators, snorkels and masks, each item should be disinfected (with sodium hypochlorite or peracetic acid) to avoid the transmission of diseases between divers.

Divers will also find it useful to attach a small PVC board with a grease pencil onto the wetsuit (or a piece of PVC pipe worn as an armband) where they can write down the times and depths of their dives and any planned decompression stops.

The diver also needs a basket or net bag for the product that is harvested, which the assistant on the vessel retrieves and empties whenever the diver asks.

As already mentioned, when decompression stops are needed, a weighted vertical rope is required that is connected to a float (or any buoy preferably fitted with a dive flag) on the surface with handles at the depth of the decompression stops (9, 6 and 3 metres). The rope is placed in the immediate vicinity of the anchored vessel for the descent, ascent and decompression of the diver (see **Figure 3**).

When using hookah diving systems, having another diver on-board with SCUBA equipment who is ready to intervene in an emergency is considered mandatory in some countries and when working with specialized companies. Additionally, again for safety reasons, these companies expect the hookah diver to carry a bailout cylinder to use if the compressor malfunctions or if anything affects the equipment (for example, if the delivery hose is severed) or if it is necessary to disconnect the diver from the vessel. It is always good practice to have an emergency air supply on-board (a cylinder with a regulator).

4.2 Assistance from the support vessel

As mentioned before, even if the assistant on-board the support vessel is not a diver, this person must have the same technical knowledge as the diver. The assistant needs to be aware of the diver's requirements, the possible operational difficulties that may arise, and of how fishing activities can be facilitated.

The support vessel should constitute a reliable base that the diver can trust, both when leaving the vessel and descending to the seabed, and when ascending and resurfacing at the end of the dive. Furthermore, the vessel must not risk moving due to difficulties in controlling a small boat using oars (**never use the engine with a diver in the water!**) when there are strong winds or currents, or if the weather conditions worsen suddenly (**Figure 17**).

Because the assistant on-board needs to check the air supply, hold the lifeline for signals, deploy and retrieve the hose, retrieve the bag containing the harvested product at intervals and monitor dive times, the vessel should be anchored before the diver enters the water and should remain anchored until the diver has resurfaced.

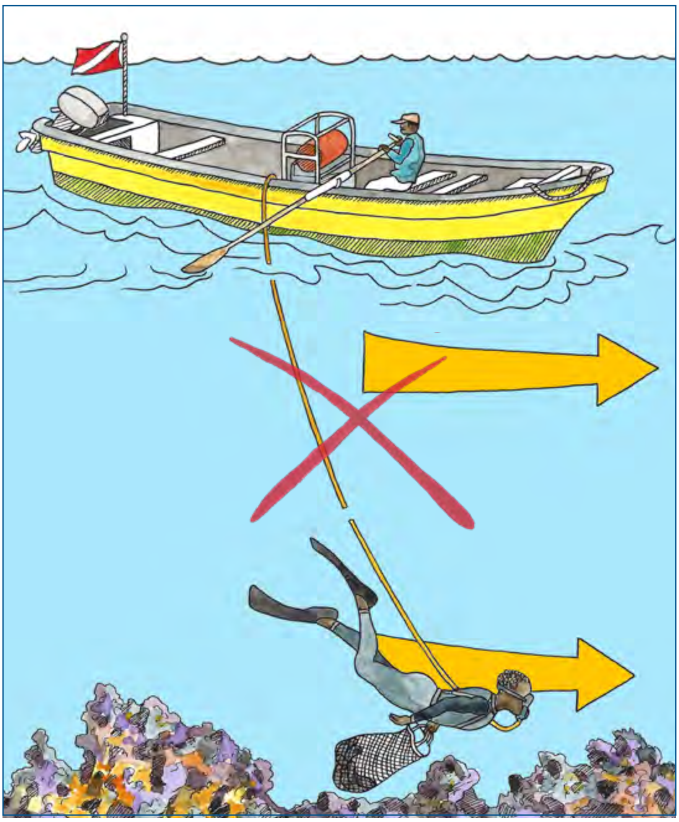


FIGURE 17. Following the diver by rowing the boat is a dangerous practice. The rowing assistant cannot perform all of the service duties, including communicating with the diver through the lifeline. In addition, winds, waves and currents can make it difficult to follow the diver.

The vessel can then be anchored in a different area for any subsequent dives. The habit of rowing the vessel to follow the diver, or rather the bubbles that resurface as the diver breathes out, is extremely risky. However, situations may occur where anchoring is not possible.

Once the vessel has arrived at the dive site and is anchored, the depth is checked with an electronic or manual depth sensor and the vessel is made stable with its bow to the wind. The assistant then lowers a rope next to the vessel, with a weight on one end and a buoy on the surface. The diver uses this to descend and ascend.

WARNING

- **Do not use the anchor line for ascending and descending (Figure 18). In order to secure the vessel, the rope attached to the anchor has to be at least three times as long as the depth; it will therefore not form a straight line between the surface and the seabed. Moreover, it is at the bow and is therefore not visible or easy to check from the vessel, and a diagonal rope will not have handles at the correct depths of 9, 6 and 3 metres for the decompression stops.**

FIGURE 18. A hookah diver ascending on an anchor line (wrong!). The anchor line generally does not drop vertically to the sea bottom, hence it should not have decompression handles as they would not be at the correct depths.

Given that the bow of an anchored boat faces into the wind, if there is a compressor on-board it must be located with its air intake towards the bow, keeping it away from the exhaust fumes that will be released towards the stern (see **Figure 15**).

The assistant then helps the diver to put on the necessary gear, checking all the equipment, and making sure that nothing is forgotten before deploying the hookah hose in the water. At this point, the assistant notes the exact time at which the diver begins descending into the water, monitoring the scheduled dive time and signalling to the diver when the bottom time is over and ascent begins, besides also signalling and timing the decompression stops.

WARNING

- **Aside from monitoring the air supply to the hookah system during the dive, the assistant is responsible for retrieving the product harvested by the diver at intervals as requested by the diver (Figure 19). This prevents the diver from resurfacing during the dive with the associated physical stress caused by equalization and loss of time that should be dedicated to the total bottom time. The basket or net bag with the product harvested needs to be attached to the vessel with a lanyard, which has a small float (one from a fishing net), placed at a distance of 3–5 metres from the diver so that it stays vertically in relation to the diver and does not interfere with the lifeline. The lanyard attached to the basket needs to be deployed during the diver's descent and fully retrieved at the end of bottom time.**

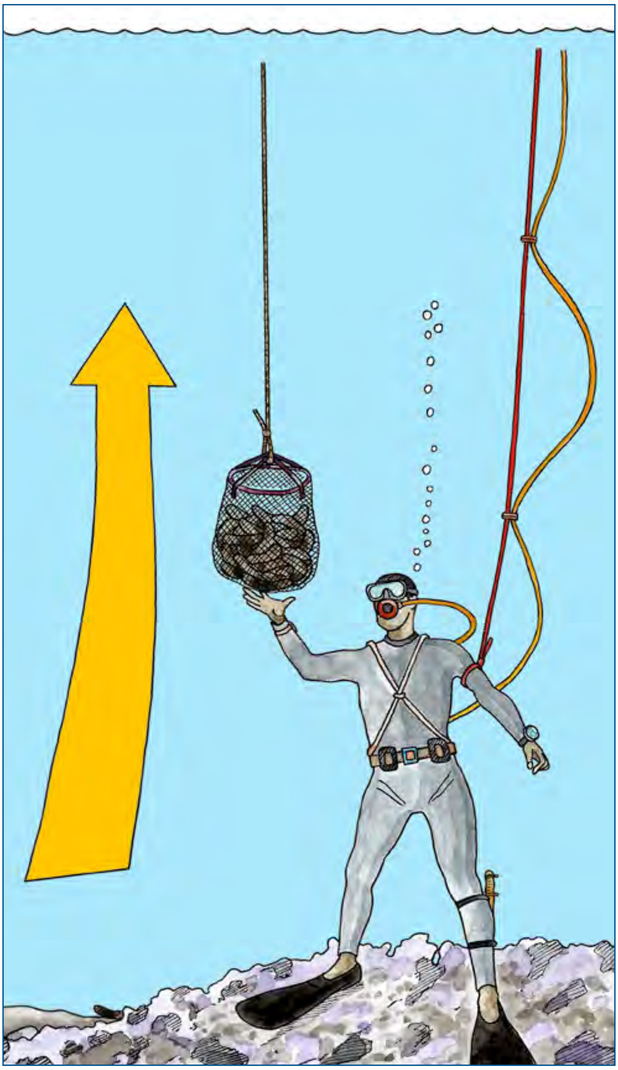


FIGURE 19. A diver with a catch basket properly tied for easy recovery from the support vessel. The diver must absolutely avoid ascending and descending several times during the dive to unload the catch basket onto the boat.

Once the diver reaches the sea bottom and has filled the basket with the catch, the lifeline is used to signal to the assistant so that the basket can be retrieved and emptied. The assistant then guides the diver to the point at which the vessel is vertically above the diver, retrieving both the lifeline and hookah hose as well as the basket lanyard. The basket is hauled out and emptied on-board then lowered back into the water towards the diver, after having been weighted so that it is able to sink.

These apparently laborious operations are, however, less complicated than if the diver has to resurface repeatedly and swim to the vessel, both considering the time and the physical stress of equalization (if this is actually successful).

Towards the end of the planned bottom time, after having sent the relative signal to the diver using the lifeline, the assistant uses this lifeline to steer the diver towards the rope that has been prepared for descent and ascent.

It is strongly discouraged for the service vessel to assist more than one diver at the same time (Figure 20).

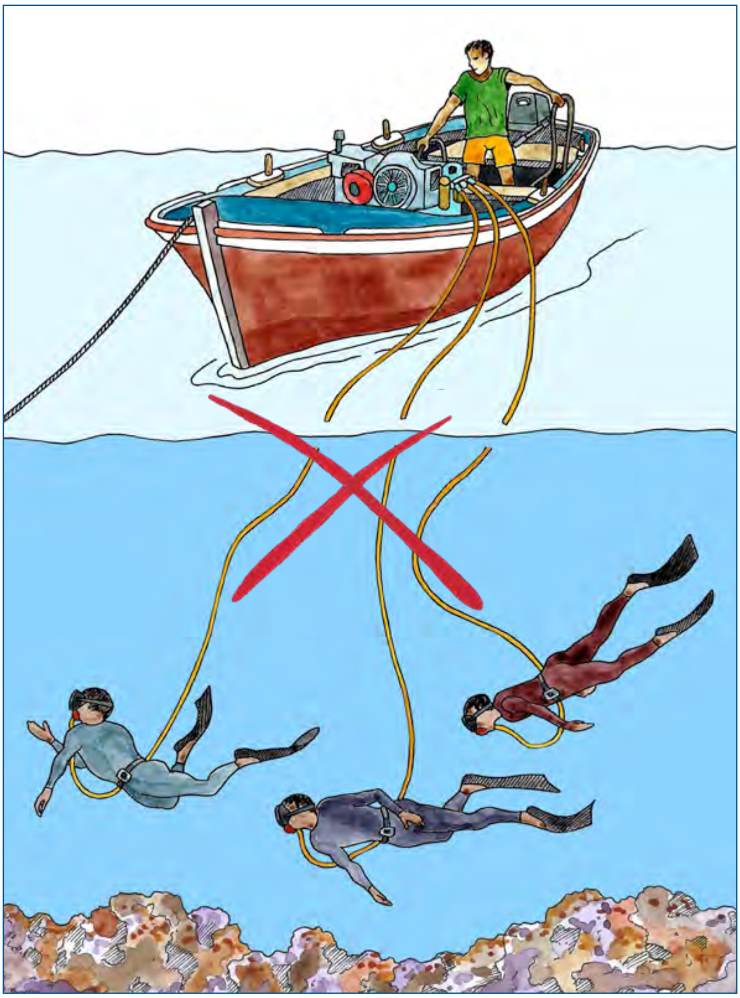


FIGURE 20. Three divers under the boat (wrong! dangerous!). It is impossible for the boat assistant to safely and properly monitor more than one diver. Furthermore, with more than one diver in the same area, the risks of uncontrollable interactions – with overlapping of lifelines, hookah hoses and basket lines – are very high.

4.3 Dive planning

The diver and the assistant must have an understanding of the area of the dive and the depth.

By way of example, we can consider a dive to be carried out at a depth of 19 metres with a planned duration of 2 hours. Because this depth is not indicated in the dive planning table, a greater depth is used: 21 metres. The bottom time must include the descent. At the recommended maximum speed of 24 metres per minute, it must take the diver at least 48 seconds to reach a depth of 19 metres: 24 metres in 60 seconds = 0.4 metres/second; therefore, 19÷0.4= 48. For 2 hours (120 minutes) of bottom time (48” descent + 119’12” on the bottom), the table indicates a 4-minute stop at a depth of 6 metres and a 47-minute stop at a depth of 3 metres. The ascent time is 2’06” at 9 metres/minute (= 0,15 metres/sec; 19÷0,15= 126”= 2 minutes and 06”), for a total ascent time of 53 minutes and 06 seconds (4’+47’+2’06”) and a repetitive group O for any subsequent dives.

These time calculations should be planned on shore before boarding the fishing vessel and written down by both the assistant and the diver on PVC boards used specifically for this purpose (Figures 21a and 21b).

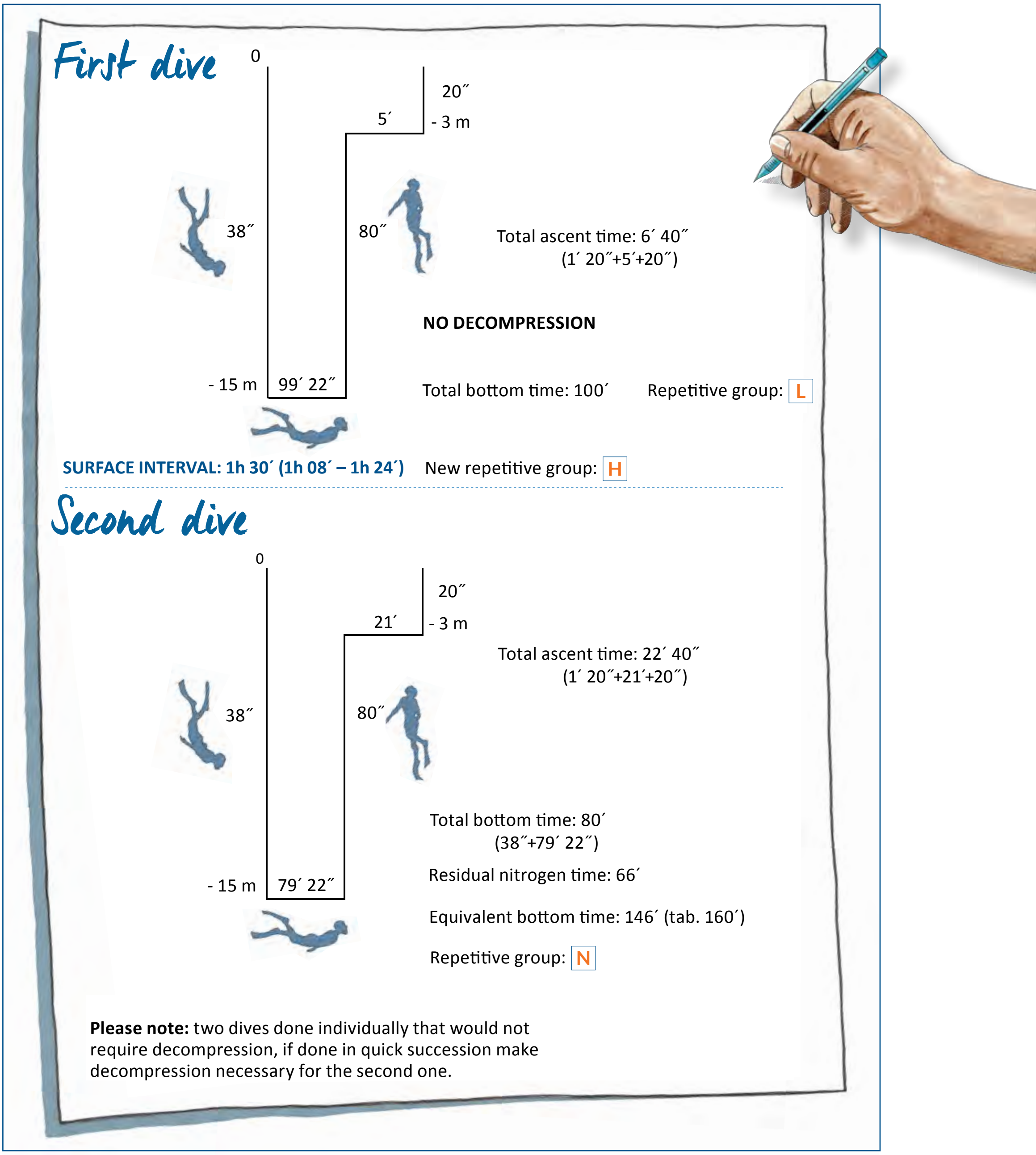


FIGURE 21a. Dive planning (for first and second dive) – The planning of a dive starts from knowing the depth to be reached, the time necessary to reach the seabed, and the time the diver wants to stay and work at the given depth. The sum of the descent time and the time spent on the seabed constitute the **total bottom time**, which for the maximum depth reached will require, or not, one or more decompression stops. Dive times and depths can be illustrated as a reminder for the diver and the assistant as shown in this figure. The same extent of planning is necessary to calculate the times of a possible subsequent dive, noting the interval times on the surface and the letters (**repetitive groups**) of exit and entry from the water, to consider the **residual nitrogen** of the first dive at the beginning of the second dive (bottom time + residual nitrogen = **equivalent bottom time**). An empty dive planning diagram is shown in Annex 8.

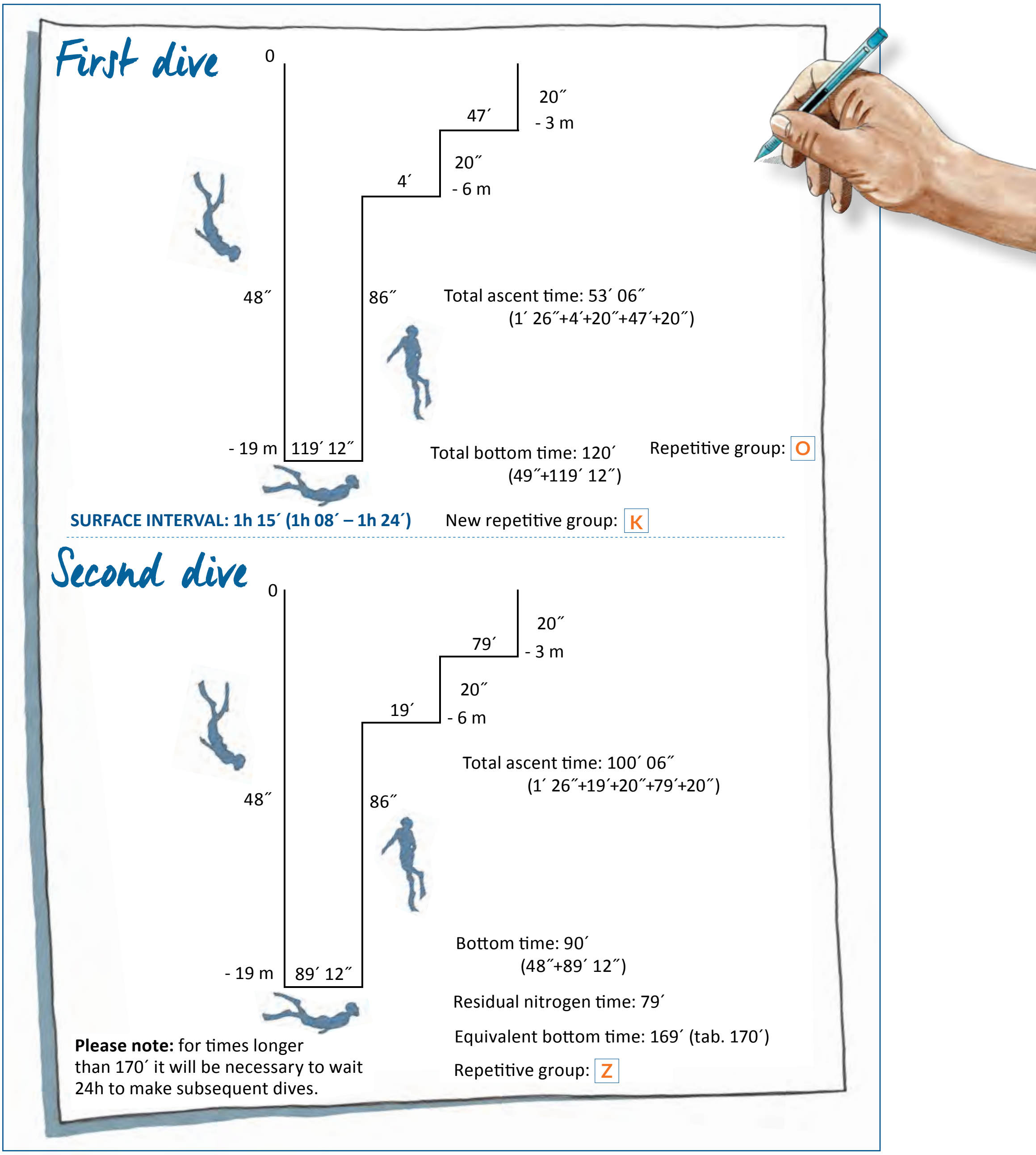


FIGURE 21b. The previous dive plan (see **Figure 21a**) indicates the times and depths of two dives which, if carried out on separate days, would not have required decompression. However, as the second dive was carried out 1h and 30′ after the end of the first dive, a decompression stop at -3 m is required. In the case of the two dives illustrated above, both require decompression stops. The first dive has a total bottom time of 120′ at a depth of -19 m while the second dive has a total bottom time of 90′ at the same depth. However, note that the second dive reaches an equivalent bottom time of 169′ which for one minute only has a repetitive group Z. If the diver had exceeded a dive of >170′ he would have had to wait 24h to carry out a subsequent dive, according to the information provided in Section 3.7 (Repetitive dives). With a repetitive group of Z, and according to the tables in Annexes 6 and 7, the diver should spent on the surface more than 1h and 37′, and less than 1h 55′ to pass to repetitive group J and have a residual nitrogen of "only" 70′ for descent to the same depth of -19 m (and consider the lower depth of -18 m in the table).

WARNING

- **If the dive proves to be particularly strenuous and tiring, a higher bottom time must be considered, using the one immediately above in the table. In this case, this would be 130 minutes instead of 120 minutes, with a stop at a depth of 6 metres for 6 minutes and another at a depth of 3 metres for 52 minutes. Plans should be made for eventualities like this and a special signal sent to the assistant on-board.**

Planning a second dive requires a calculation of the residual nitrogen from the first dive. This planning needs to take place on land before the trip starts, so that the necessary information is ready and written on a PVC board. If the time of the first dive or the surface interval between the first dive and the next dive changes for any reason, the calculations for the second dive must be made on-board after setting the anchor for a second time.

Continuing with the above example, if the diver spends at least 1 hour 08 minutes (1h 08') and less than 1 hour 24 minutes (1h 24') on the surface, the repetition group for the subsequent dive will change from group "O" to group "K", which for the same depth (so considering a depth of 18.2 metres) will result in an increase of the effective bottom time by 79 minutes.

If the actual bottom time is 90 minutes (1h 30'), it will be necessary to consider the decompression required as if this were 90+79= 169 minutes, which according to the table (170 minutes) requires a stop of 19 minutes at a depth of 6 metres and a stop of 79 minutes at a depth of 3 metres, with a total ascent time of 100 minutes and 06 seconds (19'+79'+2'06") after a 90 minutes actual bottom time on the second dive.

4.4 Descent of the diver to the seabed

Once the dive has been correctly planned, the diver who is weighted to achieve slight negative buoyancy on the surface, will go to the buoy and the assistant (who is equipped with a watch) will give a signal. The diver will start descending towards the seabed at a speed of 24 metres per minute (= 0.4 m/s) remaining in an upright position and ensuring correct ear equalization during descent. If descent proves difficult or is blocked in some way, the diver stops descending and returns towards the surface, always staying connected to the rope attached to the buoy, before starting the descent again once the problem has been solved. If it is impossible to equalize, the diver must give up the dive and return to the vessel.

WARNING: Divers normally maintain negative buoyancy to work easily on the seabed (they use weights to counteract excess buoyancy). It is very risky for divers to use their negative buoyancy to descend to the seabed in an uncontrolled way (called "freefall"); if they do this, the only way to slow descent is by swimming upwards using their fins. This makes it difficult to control the speed of descent, and makes it hard to manage any problems they have with equalization. The effort of attempting to return to the surface could also cause overexertion and fatigue.

4.5 Range of action from the support vessel

According to the safety standards of some countries, the maximum operational depth when diving with a hookah system is 20 metres. Greater depths can only be reached when several more stringent safety measures are also implemented (for example, there is a second diver on standby; the operator carries a bailout cylinder).

In practice, however, this depth is often exceeded with divers descending to depths of 30 metres and below, **an action that is strongly discouraged because the risk of accidents and fatalities increases**. In addition to the risks associated with greater depths, it also becomes awkward to handle and store the longer hookah air hose and lifeline on-board the support vessel. To get an idea of the bulk of the equipment, see **Figure 22**.

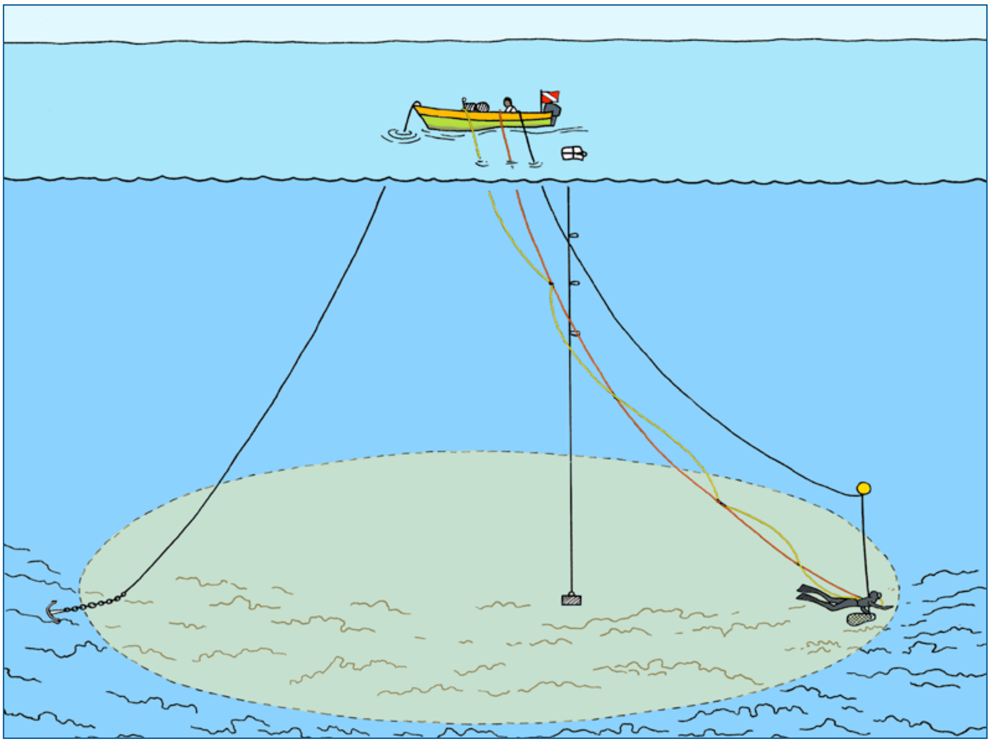


FIGURE 22. *Diver's range of action*. An example: considering a maximum vertical depth from the vessel of 25 m, and a working range of 25 m around the vessel (an area of about 2 000 m^2 in a circle under the vessel), about 35 m of hookah hose are needed. The latter is secured to a slightly shorter lifeline to avoid any force acting on the hose itself. In addition, in order to anchor the vessel at a depth of 25 m, at least 75 m of anchor line are needed, as well as another 25 m of rope to make the line that connects the surface float to the seabed to guide the ascent/descent and safety stops and 25–30 m for the basket line.

4.6 Ascent of the diver to the surface

At the end of the planned bottom time, the diver will remove the basket containing the harvested product, which the assistant on-board will retrieve. Next, the diver will reach the vertical descent/ascent line that was used to descend and that has the three handles corresponding to the decompression stops. At this point, the diver will then start to ascend at a speed of 9 metres per minute (0.15 m/s) and not faster than the exhaled air bubbles moving to the surface.

On ascent, it is crucial that divers do not hold their breath. The best way to breathe is with short inhalations and long exhalations. At the planned decompression stops, the diver should assume a horizontal position and breathe normally, remembering to exhale deeply. If the diver's bottom time does not require decompression stops, the ascent can proceed with just one precautionary stop of 5 minutes at a depth of 3 metres.

ANNEX 1

Medical examination for divers

In many countries, it is mandatory for a commercial diver to undergo a medical examination that certifies his or her state of health and psychophysical fitness to carry out work underwater. In addition, a diver is required to obtain a diving licence by taking theoretical and practical diving examinations. The medical checkup schemes are generally regulated by law and carried out by professionals that follow established protocols for both the first and yearly examinations. The list of medical tests required, and disqualifying conditions, considered by the Association of Diving Contractors International Inc. (ADCI), United States of America, is given as an example and guidance.

Test	Note and comments
History and physical	Includes the predisposition to unconsciousness, vomiting, cardiac arrest, impairment of oxygen transport, serious blood loss or anything that, in the opinion of the examining physician, will interfere with effective underwater work.
Chest X-ray	Postero-anterior and bilateral, every three years unless medical conditions dictate otherwise.
Bone and joint X-ray survey	Optional and as medically indicated.
EKG – standard	Optional initially to establish baseline, annually after age 35.
EKG – stress test	Required as medically indicated if the Framingham Risk Score indicates risk of >10 percent.
Spirometry	Required, including Forced Vital Capacity, Forced Expiratory Volume, and Forced Expiratory Flow.
Audiogram	Threshold audiogram by pure tone audiometry; bone conduction audiogram as medically indicated.
EEG	Required only as medically indicated.
Visual acuity	Required initially and annually.
Color blindness	Required.
Complete blood count	Required.
Routine urinalysis	Required.
Sickle cell screen	Optional.
TB screening	Optional.
Comprehensive metabolic profile	Optional, including cholesterol and triglycerides required for divers over 40 years of age.
Lipid panel	Required annually after the age of 35.
Framingham Risk Score (coronary risk factor)	Required annually after the age of 35.

ANNEX 1. (continued) – Medical examinations for divers

Disqualifying conditions
A person having any of the following conditions, as determined by a doctor's examination, shall be disqualified from engaging in diving or other hyperbaric activities: ► History of seizure disorder other than early childhood febrile conditions. ► Cystic, bullous or cavitary disease of the lungs, significant obstructive or restrictive lung disease and/or spontaneous pneumothorax. ► Chronic inability to equalize sinus and middle ear pressure. ► Significant central or peripheral nervous system disease or impairment. ► Chronic alcoholism, drug abuse, dependence, or history of psychosis. ► Hemoglobinopathies associated with comorbidities. ► Any person engaged as a diver, or otherwise exposed to hyperbaric conditions, will have a medical examination following any non-diving injury or illness that requires any prescription medication, any surgical procedure or any hospitalization. ► Untreated or persistent/metastatic or other significant malignancies, including those that require chemotherapy and/or radiation therapy unless five years after treatment with no evidence of recurrence. ► Hearing impairment in the better ear should be at least 40 dB average in the 500, 1 000 and 2 000 Hz frequencies. ► Juxta-articular osteonecrosis. ► Chronic conditions requiring continuous control by medication that increases risks in diving.

See also:

"*The Medical Examination and Assessment of Commercial Divers*" of Health and Safety Executive (HSE – UK), used by HSE Approved Medical Examiners of Divers (AMEDs) in performing fitness to dive medicals for the purposes of the Diving at Work Regulations 1997 (MA1). They are intended to influence professional practice and, as a consequence, enhance the quality and reduce any unnecessary variability of fitness to dive assessments undertaken by HSE AMEDs.

The standards and guidelines reflect the need to protect the health, safety and welfare of divers at work. They take account of the mental and physical requirements for meeting reasonably foreseeable underwater emergencies and the physiological effects of working in a hyperbaric environment.

ANNEX 2

Questionnaire – Testing basic diving knowledge

The questions listed below can be useful to assess the level of learning that a hookah diver (or candidate diver) has acquired by reading this basic hookah diving guide. The knowledge required to answer correctly all questions is essential for working underwater safely. It is therefore important that all hookah fishers answer all questions correctly. Continue self-training or through the assistance of qualified Fishery Extension Officers should endure until all questions are properly answered.

Test questions	Correct	Not correct
1. What basic features must a compressor have in order to supply breathable air?	☐	☐
2. What are the main differences between a hookah system supplied by a compressor and one supplied by high-pressure cylinders?	☐	☐
3. What is the regulator used for?	☐	☐
4. When descending from the surface to the seabed, what must you do to avoid a ruptured eardrum? How should this be done?	☐	☐
5. What is the maximum speed of descent to the seabed?	☐	☐
6. When ascending to the surface, can you go faster than the air bubbles formed by the air you exhale?	☐	☐
7. When ascending to the surface while breathing compressed air, should you hold the air in your lungs or continue breathing and exhaling deeply?	☐	☐
8. What is the total pressure that a human body experiences at a depth of 20 metres?	☐	☐
9. What gases make up air?	☐	☐
10. When you dive using compressed air to breathe underwater, what happens to the nitrogen that you breathe in?	☐	☐
11. What happens to the nitrogen in your blood and in the tissues of your body when you ascend to the surface after a dive using compressed air to breathe underwater?	☐	☐
12. What do decompression tables tell us?	☐	☐
13. When can decompression sickness occur and why?	☐	☐
14. What should you do if you develop symptoms of decompression sickness on resurfacing from a dive made using compressed air to breathe underwater?	☐	☐
15. Use the decompression tables to plan a dive at a depth of 13 metres with a bottom time of 115 minutes.	☐	☐
16. Plan a second dive one hour after the first dive in Question 15 at a depth of 16 metres with a bottom time of 90 minutes.	☐	☐
17. What should you do if, before diving, you realize that you do not have a watch or that your watch does not work?	☐	☐
18. If a diver consumes 8 litres of air/minute at the surface, how much air will the diver need to spend one hour at a depth of 20 metres?	☐	☐

ANNEX 3

Glossary of medical terms

Asphyxia:	Also known as suffocation, is the condition in which the absence or scarcity of oxygen prevents normal breathing.
Asthma:	Is a syndrome (or complex of symptoms) characterized by increased resistance in the airways. Common trigger include allergic reaction, cold, humidity or dryness.
Claustrophobia:	Fear of closed, confined spaces and places from which escape would be difficult or impossible.
Coronary disease:	Result of narrowing of the coronary arteries due to fatty deposits on the internal walls, with reduced blood flow.
Diabetes:	Is a disease in which there is an increase in blood sugar levels due to a deficit in the quantity and/or biological efficiency of insulin (hormone that controls blood sugar).
Dehydratation	A state in which body tissues do not have enough water to function normaly.
Emphysema:	Lung disease characterized by an anatomical alteration of the alveoli and in some cases of the bronchioles, with more or less severe breathing difficulties.
Epilepsy:	Neurological disorder characterized by the presence and repetition over time of sudden involuntary crises with muscle contractions and spasms.
Gas embolism:	Pathological condition that arises when one or more air bubbles block the flow of blood within a blood vessel.
Haemorrhage:	Blood leaking from vessels (arteries, veins).
Hypertension:	Pathological condition characterized by the constant presence of resting blood pressure levels in the arteries above normal.
Mucous membranes:	Lining membranes of the internal surface of hollow organs and canals of the body (in the respiratory tract, gastrointestinal tract, urinary tract, genital system, middle ear, etc.)
Myocarditis:	Is an inflammation of the muscle tissue of the heart that causes the tissue to die.
Obesity:	Excessive accumulation of body fat in relation to lean mass in terms of absolute quantity and distribution in specific points of the body.
Pneumonia:	Acute or chronic inflammation of the lung parenchyma.
Pneumothorax:	Sudden onset disease characterized by air in the pleural space (between the lung and chest wall) also called collapsed lung.
Tuberculosis:	An infectious disease caused by a bacterium. In most cases it affects the lungs.
Ulcers:	Lesion of the skin or of an epithelial tissue with slow or no healing.

ANNEX 4

Standard decompression tables

(**Descent rate** 24 metres/min = 75 feet/min || **Ascent rate** 9 metres/min = 30 feet/min)

Decompression stops (m/ft) Stop times (min) include travel times except first stop										
				Metres (m) / Feet (ft)						
Depth (m)	Depth (ft)	Bottom time (min)	Time first stop (min:sec)	15.2/50	12.1/40	9.1/30	6.0/20	3.0/10	Total decompression time (min:sec)	Repetitive dive group
		200						0	01:20	*
		210	01:00					2	03:20	N
		230	01:00					7	08:20	N
		250	01:00					11	12:20	O
		270	01:00					15	16:20	O
12.2	40	300	01:00					19	20:20	Z
		360	01:00					23	24:20	**
		480	01:00					41	42:20	**
		720	01:00					69	70:20	**
		100						0	01:40	*
		110	01:20					3	4.40	L
		120	01:20					5	6.40	M
		140	01:20					10	11:40	M
15.2	50	160	01:20					21	22:40	N
		180	01:20					29	30:40	O
		200	01:20					35	36:40	O
		220	01:20					40	41:40	Z
		240	01:20					47	48:40	Z
		60						0	02:00	*
		70	01:40					2	04:00	K
		80	01:40					7	09:00	L
		100	01:40					14	16:00	M
		120	01:40					26	28:00	N
		140	01:40					39	41:00	O
		160	01:40					48	50:00	Z
18.2	60	180	01:40					56	58:00	Z
		200	01:20				1	69	72:00	Z
		240	01:20				2	79	83:00	**
		360	01:20				20	119	141:00	**
		480	01:20				44	148	194:00	**
		720	01:20				78	187	267:00	**

ANNEX 4. (continued) – Standard decompression tables

Decompression stops (m/ft) Stop times (min) include travel times except first stop										
				Metres (m) / Feet (ft)						
Depth (m)	Depth (ft)	Bottom time (min)	Time first stop (min:sec)	15.2/50	12.1/40	9.1/30	6.0/20	3.0/10	Total decompression time (min:sec)	Repetitive dive group
		50						0	02:20	*
		60	02:00					8	10:20	K
		70	02:00					14	16:20	L
		80	02:00					18	20:20	M
		90	02:00					23	25:20	N
		100	02:00					33	35:20	N
		110	01:40				2	41	45:20	O
21.3	70	120	01:40				4	47	53:20	O
		130	01:40				6	52	60:20	O
		140	01:40				8	56	66:20	Z
		150	01:40				9	61	72:20	Z
		160	01:40				13	72	87:20	Z
		170	01:40				19	79	100:20	Z
		40						0	02:40	*
		50	02:20					10	12:40	K
		60	02:20					17	19:40	L
		70	02:20					23	25:40	M
		80	02:00				2	31	35:40	N
		90	02:00				7	39	48:40	N
		100	02:00				11	46	59:40	O
		110	02:00				13	53	68:40	O
		120	02:00				17	56	75:40	Z
24.4	80	130	02:00				19	63	84:40	Z
		140	02:00				26	69	97:40	Z
		150	02:00				32	77	111:40	Z
		180	02:00				35	85	122:40	**
		240	01:40			6	52	120	180:40	**
		360	01:40			29	90	160	281:40	**
		480	01:40			59	107	187	355:40	**
		720	01:20		17	108	142	187	456:40	**

ANNEX 4. (continued) – Standard decompression tables

Decompression stops (m/ft) Stop times (min) include travel times except first stop										
				Metres (m) / Feet (ft)						
Depth (m)	Depth (ft)	Bottom time (min)	Time first stop (min:sec)	15.2/50	12.1/40	9.1/30	6.0/20	3.0/10	Total decompression time (min:sec)	Repetitive dive group
		30						0	03:00	*
		40	02:40					7	10:00	J
		50	02:40					18	21:00	L
		60	02:40					25	28:00	M
		70	02:20				7	30	40:00	N
		80	02:20				13	40	56:00	N
28.4	90	90	02:20				18	48	69:00	O
		100	02:20				21	54	78:00	Z
		110	02:20				24	61	88:00	Z
		120	02:20				32	68	103:00	Z
		130	02:00			5	36	74	118:00	Z
		25						0	03:20	*
		30	03:00					3	06:20	I
		40	03:00					15	18:20	K
		50	02:40				2	24	29:20	L
		60	02:40				9	28	40:20	N
		70	02:40				17	39	59:20	O
		80	02:40				23	48	74:20	O
		90	02:20			3	23	57	86:20	Z
30.5	100	100	02:20			7	23	66	99:20	Z
		110	02:20			10	34	72	119:20	Z
		120	02:20			12	41	78	134:20	Z
		180	02:00		1	29	53	118	204:20	**
		240	02:00		14	42	84	142	285:20	**
		360	01:40	2	42	73	111	187	418:20	**
		480	01:40	21	61	91	142	187	505:20	**
		720	01:40	55	106	122	142	187	615:20	**

* See no-decompression table for repetitive groups (Annex 5).

** Repetitive dives may not follow exceptional exposure dives.

Source: US Navy air decompression tables and recompression chamber operator´s handbook. Revision September 1995. Best Publishing Company. (These tables remained valid and unchanged until 2008).

ANNEX 5

No-decompression limits and repetitive group designators for no-decompression air dives

The table shows the maximum bottom time with no decompression and the group designation after the no-decompression dive is completed. The diver can find the group designation assigned after the first dive by finding the bottom time spent at the maximum depth on the top of the corresponding column. For example: a dive at 21 metres depth for 35 minutes assigns the diver to group G; this must be considered when calculating the bottom time of a second dive, while also considering any surface interval (see Annex 6).

Depth (m)	Depth (ft)	No-stop limit (min)	Repetitive group designation														
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
			Dive minutes														
3.0	10	Unlimited	60	120	210	300											
4.6	15	Unlimited	35	70	110	160	225	350									
6,1	20	Unlimited	25	50	75	100	135	180	240	325							
7.6	25	Unlimited	20	35	55	75	100	125	160	195	245	315					
9.1	30	Unlimited	15	30	45	60	75	95	120	145	170	205	250	310			
10.7	35	310	5	15	25	40	50	60	80	100	120	140	160	190	220	270	310
12.2	40	200	5	15	25	30	40	50	70	80	100	110	130	150	170	200	
15.2	50	100		10	15	25	30	40	50	60	70	80	90	100			
18.2	60	60		10	15	20	25	30	40	50	55	60					
21.3	70	50		5	10	15	20	30	35	40	45	50					
24.4	80	40		5	10	15	20	25	30	35	40						
27.4	90	30		5	10	12	15	20	25	30							
30.5	100	25		5	7	10	15	20	22	25							

Source: US Navy air decompression tables and recompression chamber operator´s handbook. Revision September 1995. Best Publishing Company. (These tables remained valid and unchanged until 2008).

ANNEX 6

Surface interval credit for subsequent dives (time expressed in hours:minutes)

When a diver is assigned to a dive group after a first dive, the time spent on the surface reduces the amount of nitrogen in the organs and tissues, thus the diver can change the repetitive group according to the surface interval time between the first and the second dive. The new group can be assigned according to the letter in the yellow field, which is in correspondence of the time spent between two dives on the row of the initial group in the blue fields. For example: after the first dive of 80 minutes at a depth of 27 metres, the diver surfaces for 3:00 hours. In this case, the starting group is N (see Annex 4). In the blue field, locate "N" and find the time spent on the surface along the same row (in this case, it will be the lower one, 2:47 hours) and the corresponding letter in the yellow fields (group G) will be the new group to be considered for the next dive.

ANNEX 6 next page ▸

ANNEX 6. Surface interval credit for subsequent dives (time expressed in hours:minutes)

Residual nitrogen timetable for repetitive air dives

Locate the diver's repetitive group designation from his/her previous dive along the diagonal line above the table. Read horizontally to the interval in which the diver's surface interval lies.

Next read vertically downward to the new repetitive group designation (**Annex 7**). Continue downward in this same column to the row which represents the depth of the repetitive dive. The time given at the intersection is residual nitrogen time, in minutes, to be applied to the repetitive dive.

Repetitive group at the beginning of the surface interval

A >																00:10 12:00*
B >															00:10 03:20	03:21 12:00*
C >														00:10 01:39	01:40 04:49	04:50 12:00*
D >													00:10 01:09	01:10 02:38	02:39 05:48	05:49 12:00*
E >												00:10 00:54	00:55 01:57	01:58 03:24	03:25 06:34	06:35 12:00*
F >											00:10 00:45	00:46 01:29	01:30 02:28	02:29 03:57	03:58 07:05	07:06 12:00*
G >										00:10 00:40	00:41 01:15	01:16 01:59	02:00 02:58	02:59 04:25	04:26 07:35	07:36 12:00*
H >									00:10 00:36	00:37 01:06	01:07 01:41	01:42 02:23	02:24 03:20	03:21 04:49	04:50 07:59	08:00 12:00*
I >								00:10 00:33	00:34 00:59	01:00 01:29	01:30 02:02	02:03 02:44	02:45 03:43	03:44 05:12	05:13 08:21	08:22 12:00*
J >							00:10 00:31	00:32 00:54	00:55 01:19	01:20 01:47	01:48 02:20	02:21 03:04	03:05 04:02	04:03 05:40	05:41 08:50	08:51 12:00*
K >						00:10 00:28	00:29 00:49	00:50 01:11	01:12 01:35	01:36 02:03	02:04 02:38	02:39 03:21	03:22 04:19	04:20 05:48	05:49 08:58	08:59 12:00*
L >					00:10 00:26	00:27 00:45	00:46 01:04	01:05 01:25	01:26 01:49	01:50 02:19	02:20 02:53	02:54 03:36	03:37 04:35	04:36 06:02	06:03 09:12	09:13 12:00*
M >				00:10 00:25	00:26 00:42	00:43 00:59	01:00 01:18	01:19 01:39	01:40 02:05	02:06 02:34	02:35 03:08	03:09 03:52	03:53 04:49	04:50 06:18	06:19 09:28	09:29 12:00*
N >			00:10 00:24	00:25 00:39	00:40 00:54	00:55 01:11	01:12 01:30	01:31 01:53	01:54 02:18	02:19 02:47	02:48 03:22	03:23 04:04	04:05 05:03	05:04 06:32	06:33 09:43	09:44 12:00*
O >		00:10 00:23	00:24 00:36	00:37 00:51	00:52 01:07	01:08 01:24	01:25 01:43	01:44 02:04	02:05 02:29	02:30 02:59	03:00 03:33	03:34 04:17	04:18 05:16	05:17 06:44	06:45 09:54	09:55 12:00*
Z >	00:10 00:22	00:23 00:34	00:35 00:48	00:49 01:02	01:03 01:18	01:19 01:36	01:37 01:55	01:56 02:17	02:18 02:42	02:43 03:10	03:11 03:45	03:46 04:29	04:30 05:27	05:28 06:56	06:57 10:05	10:06 12:00*
New group designation	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A

* Dives following surface intervals of more than 12 hours are not repetitive dives. Use actual bottom times in the standard air decompression tables to compute decompression for such dives.

Source: US Navy air decompression tables and recompression chamber operator´s handbook. Revision September 1995. Best Publishing Company. (These tables remained valid and unchanged until 2008).

ANNEX 7

Residual nitrogen time for subsequent dives

Starting from the new group identified, considering the interval on the surface with the use of the table in Annex 6, this table shows the minutes to be added to the bottom time of the next dive, according to the maximum depth in which it will be carried out. For example: continuing with the previous example in Annex 6, if the new group is G and the next dive reaches -18 metres, the diver will need to add 44 minutes to the bottom time. If in the next dive the bottom time will be 80 minutes, the necessary decompression will be that of (80 + 44) 124 minutes. As this time is not indicated in the table, the diver will need to select the next higher value, which is that of 140 minutes: 39 minutes at -3 metres.

Residual nitrogen times (minutes)

Repetitive dive depth feet-metres	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
10–3.0	**	**	**	**	**	**	**	**	**	**	**	**	279	159	88	39
20–6.1	**	**	**	**	**	**	**	399	279	208	159	120	88	62	39	18
30–9.1	**	**	469	349	279	229	190	159	132	109	88	70	54	39	25	12
40–12.2	257	241	213	187	161	138	116	101	87	73	61	49	37	25	17	7
50–15.2	169	160	142	124	111	99	87	76	66	56	47	38	29	21	13	6
60–18.2	122	117	107	97	88	79	70	61	52	44	36	30	24	17	11	5
70–21.3	100	96	87	80	72	64	57	50	43	37	31	26	20	15	9	4
80–24.4	84	80	73	68	61	54	48	43	38	32	28	23	18	13	8	4
90–27.4	73	70	64	58	53	47	43	38	33	29	24	20	16	11	7	3
100–30.5	64	62	57	52	48	43	38	34	30	26	22	18	14	10	7	3

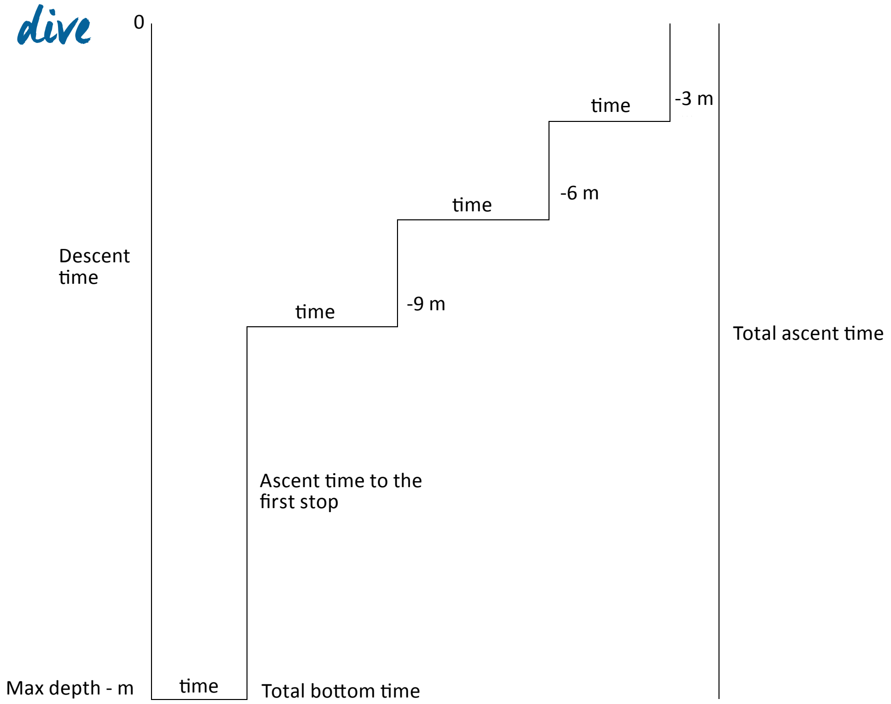
** If no Residual Nitrogen Time is given, then the repetitive group does not change.

Source: US Navy air decompression tables and recompression chamber operator´s handbook. Revision September 1995. Best Publishing Company. (These tables remained valid and unchanged until 2008).

ANNEX 8

Dive planning

First dive

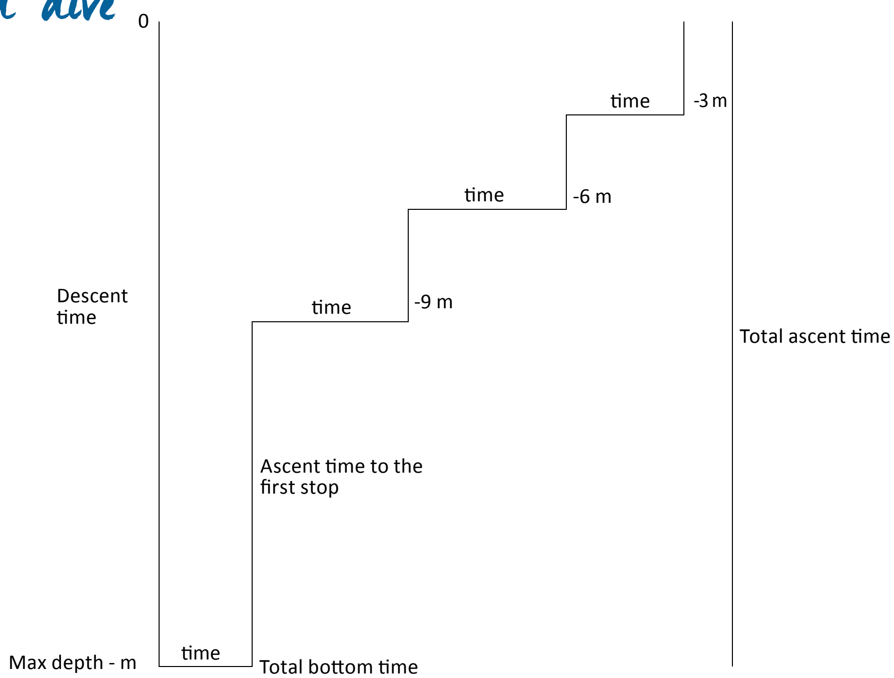


Repetitive group at the end of 1st dive: ....

SURFACE INTERVAL: ....

Repetitive group at the start of 2nd dive (at depth: .....): ....

Second dive



Residual nitrogene time

Repetitive group: ....

Equivalent bottom time

ANNEX 9

Diving equipment checklist

The market provides diving equipment from many different manufacturers. Local dive stores should be consulted and the most appropriate equipment purchased. The table below lists the key diving equipment required and recommended for hookah diving while also providing some tips on the features, which should assist with selecting the correct item.

©Cressi

WETSUIT
Neoprene, better if lined with fabric, must be of the right size, not tight to hinder breathing, blood circulation and movements, nor too large to allow entry of excess water. It should cover the entire body, from wrist to ankle, have a hood and possibly be completed with boots. The thickness must be suitable for the water temperature (from 3 to 5 mm). Different models of wetsuits exist, including those that have a separate hood or that do not provide full coverage (known as “shorty” with short legs and sleeves).


©Cressi

MASK
It is important that the mask adheres well to the diver’s face (suction cup effect when worn) and does not allow water to enter inside while diving. The mask should fit comfortably and not worn too tight over the head. The mask, although generally made of high-quality silicone, should not be left in the sun. The tempered glass should be regularly cleaned and the entire mask rinsed with freshwater before storage.


©Mares

SNORKEL
The snorkel is better if fitted with a large tube section, with a comfortable mouthpiece and with a smooth, rounded bend to avoid breathing resistance. It should always be worn during the dive and used by the diver when at the surface. While the diver swims at the surface, the snorkel is of great help in case no air supply is delivered through the hookah hose.

©Cressi

FINS
They must be the right size for the foot of the diver. If neoprene booties are used, fins fitted with a strap closure mechanisms are preferable (or “open-heeled fins”). The fin blade should neither be too soft nor too hard.

ANNEX 9. (Continued) – **Diving equipment checklist**

©Cressi

WEIGHT BELT

A dive weight belt should be made of strong and long-lasting material. In addition to robustness, a quick-release buckle and the ease in adjusting the belt length are important characteristics of a dive weight belt. Lead blocks are the most common weights in use.


©Mares

KNIFE

The dive knife should come with its own sheath that can be strapped to the leg or wrist of the diver. It does not need to be particularly sharp nor have a blade of particular dimensions. The sturdiness and quality of stainless steel are important against corrosion. Knives with a fixed blade are generally considered to be more reliable.

©Cressi

DEPTH GAUGE

The depth gauge will indicate the maximum depth reached by the diver. Many models exist but an analog depth gauge with fluorescent numbers, easy readability and precision is generally a sturdy instrument and widely used.


©Mares

REGULATOR

A diving regulator is a pressure regulator that controls the pressure of breathing gas for diving. It reduces the pressurized breathing gas to ambient pressure and delivers it to the diver. The regulator is a delicate instrument to be handled with care, safeguarding the integrity of all its parts: first, second stage and connecting tube between them. It is important to understand its operation and ordinary maintenance, to periodically clean the second stage and apply silicon to the diaphragm and levers.

©Mares

PVC BOARD (for dive planning)

A white diving PVC board that can be secured to the diver and equipped with a grease pencil is a useful dive accessory. The diver can mark a dive plan and take it along for reference.

©Cressi

TORCH

A dive torch can be an invaluable instrument when diving in poor visibility conditions (at dusk, for example). A preferred torch must be powerful, must float, be small and be absolutely waterproof. Dive torches can also be useful tools to signal to other divers.

©Cressi

WATCH

A dive watch must be precise and specifically designed to be worn while underwater. It should have sturdy features like screw-down crowns, unidirectional rotating bezels, luminous hands and markers, and fitted with scratch-resistant glass. Absolute waterproof is essential (at least up to -100 m). It is also important that the dive watch has a sturdy adjustable strap.

©Mares

DIVE COMPUTER

Different models of dive computers exist; some are complex, while others are basic and cheaper. These computers are widely used and should be considered an important piece of dive gear for all divers because they provide real-time information on the dive. A dive computer should show on its display the basics at a glance. These include maximum depth, current depth, dive time, and no-fly/no-stop time.

©Mares

BUOYANCY CONTROL DEVICE

The buoyancy control device (BCD) is a device that gives a SCUBA diver control over buoyancy during a dive. Basically, the BCD allows the diver to inflate or deflate the device of air, allowing the diver to sink or rise when in the water and to maintain neutral buoyancy at a specific depth with minimal physical effort. Different types and models of BCD exist, with simple models possibly more suitable for hookah diving.

IMPORTANT

Remember, before diving, a diver should carry out the following security checks:

Air hose condition	Ascent/descent anchor line
Compressor filter	Lifeline
Quantity of compressor fuel on board	Torch batteries

ANNEX 10

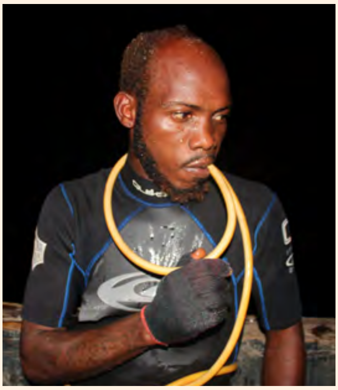
Selected photos – Attention to bad practices

©S. Herrera-Kasic

Support boat with rowing assistant and the diver who prepares the equipment for the dive. Following the diver's bubbles does not allow the assistant to carry out other necessary activities, such as releasing and recovering the hookah hose and the lifeline (and receiving and sending signals), checking the compressor, and recovering the catch basket with the product and sending it back to the bottom after emptying it. Operating the support boat in strong winds, marine currents and rough seas is dangerous and thus discouraged.

©T. Collinson

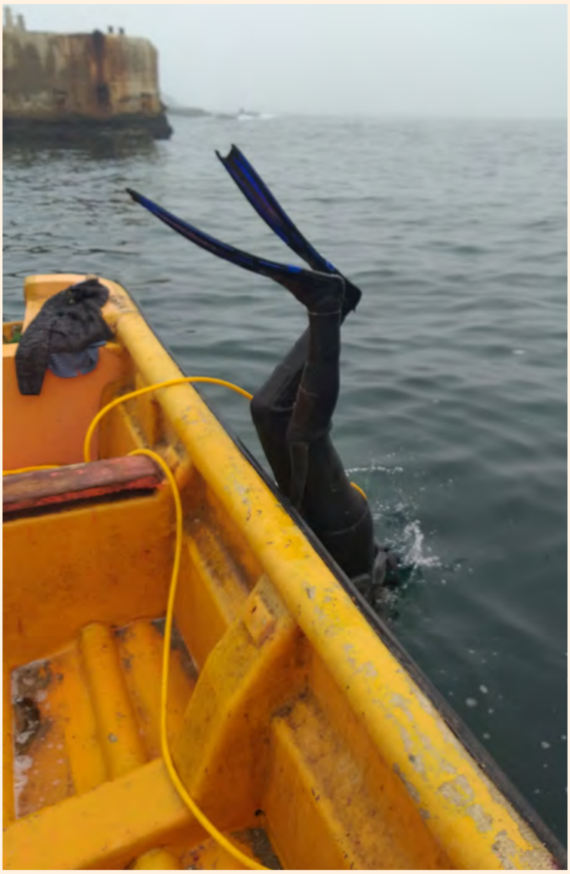
The diver prepares for the dive. The assistant stepping on the hose risks damaging it. In addition, the hookah hose, instead of being secured on the diver's back with a harness, is connected to the regulator in an arranged way and is also tied around the diver's waist. These are hazards that can lead to accidents due to damaging or crushing of the hose or detachment of the regulator. The diver has neither a depth gauge nor a watch.



©T. Collinson

©T. Collinson

These divers breathe the air directly from the hose without a regulator; they regulate the flow by squeezing the hose between their teeth. The divers are breathing incorrectly because this method does not allow to breathe air at the right pressure.



©S. Herrera-Kasic

Diver entering the water. After checking the equipment, the entry into the water should be done sitting on the side of the boat and diving back first. The descent to the bottom should be done from a line attached to a buoy and anchored vertically to the bottom. The diver slowly descends in an upright or horizontal position.

©S. Herrera-Kasic

Compressor provided by a public administration. Although made of sturdy material and equipped with an air reserve tank, the compressor has no adequate filters and devices for draining condensate water. Furthermore, the air intake is not far from the engine exhaust, which can cause toxic particles to enter the compressed air.

©T. Collinson

A “homemade” compressor without filters is not suitable for breathing air and does not allow condensation water to discharge. The air intake is near the exhaust of the combustion engine. In the foreground, the connection for supplying air to four hoses (divers) at the same time is clearly visible on the tank: this is an extremely dangerous practice that makes any assistance from the boat impossible and the risk of accidents very high.

©S. Herrera-Kasic

A compressor is connected to a larger air reserve tank. Filters are visible at the tank outlet rather than on the compressor itself, and it remains impossible to have air intake away from engine exhaust.

Notes and observations:

The gathering of commercial benthic organisms from the seabed by underwater fishers through hookah diving is a growing activity in many seas across the world.

Sea cucumbers are particularly targeted as they are in great demand.

Unfortunately, many sea cucumber fishers still operate with little or no formal training in safe diving practices, are poorly equipped, and are breathing compressed air supplied by hookah systems frequently powered by improvised compressors.

Working under such poor conditions makes hookah diving a risky and unsafe activity that often leads to accidents that may result in death or permanent disability of fishers.

This guide aims at providing fishers, as well as fishery extension officers, with a tool to help them acquire the basic knowledge needed to carry out hookah diving safely. Through simple language and numerous illustrations, the guide describes the basic rules of diving, the potential risks associated with this activity and what to do to minimize them, as well as other useful tips to improve hookah diving operations.

The guide, however, is not intended as a comprehensive manual for commercial divers, and it is strongly recommended that fishers who want to engage in hookah or SCUBA diving undertake appropriate training by a qualified diving instructor.

ISBN 978-92-5-137476-4

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