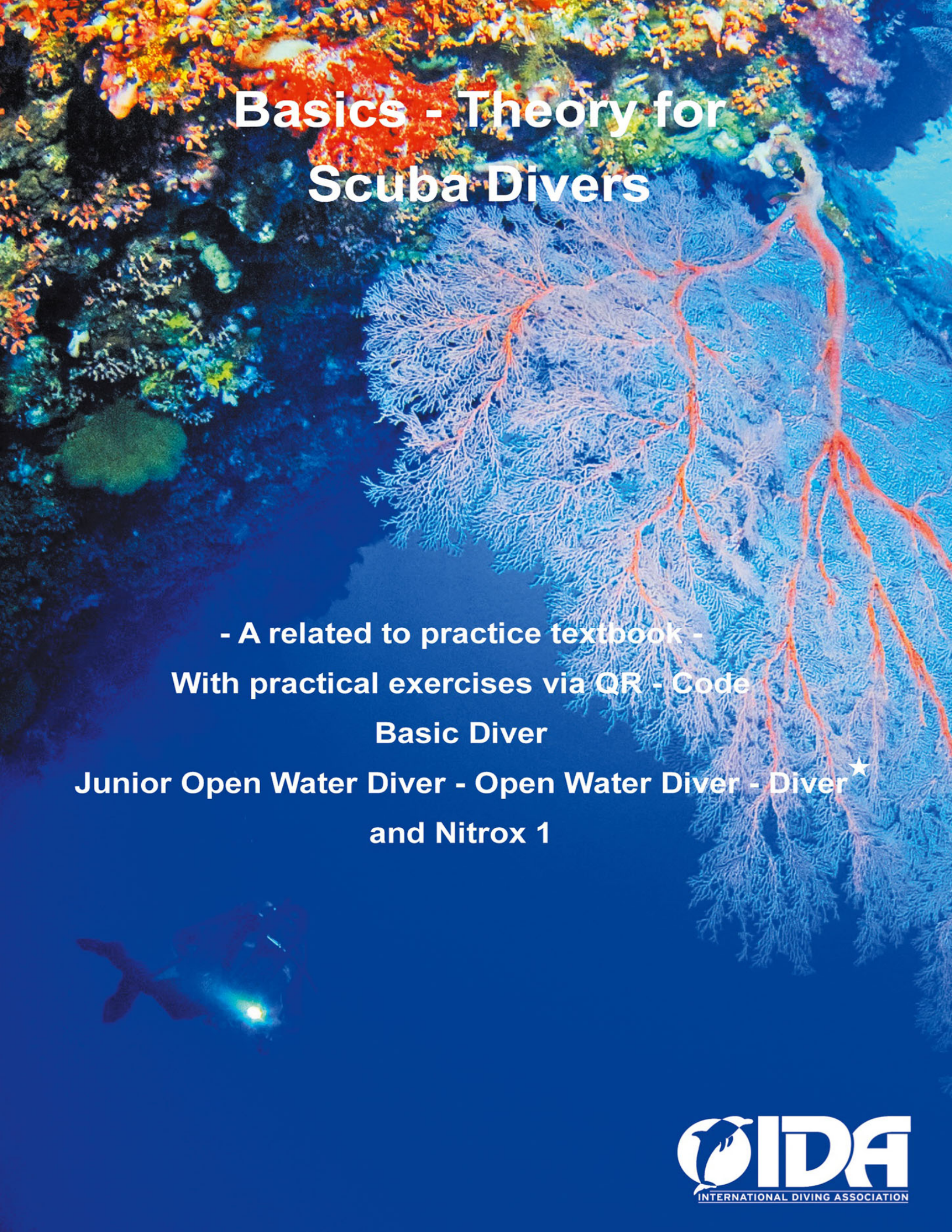
Basics - Theory for Scuba Divers



- A related to practice textbook -

With practical exercises via QR - Code

Basic Diver

Junior Open Water Diver - Open Water Diver - Diver★

and Nitrox 1

IDA

INTERNATIONAL DIVING ASSOCIATION

All information contained in this book has been compiled to the best of my knowledge and based on decades of experience in the training of scuba divers and instructors. But since I am just a human, of course, mistakes could be possible, although I have had this book proofread by many other professionals. Thus, I can at least shift some of the blame to others, if this book should nevertheless contain mistakes. I am very sure that this book contains no serious mistakes and thus cannot provoke diving accidents. Nevertheless, I decline any liability, obligation or guarantee, should it come to an accident due to reading my book or due to any inaccuracy in this book. Therefore, I strongly recommend that you use this book only as a companion and as part of a professional dive training course by a professional instructor certified by a recognized association **(CMAS or R.S.T.C.)**. Even though there are no legal requirements for recreational divers in some countries, you should not go underwater with the SCUBA equipment without professional help. Protected trade names or trademarks or logos are not always specially marked. From the lack of such evidence cannot be concluded that it is a free brand name, a free trademark or a free company logo. Make sure before you commit a trademark infringement, because that could be very expensive for you. Not all companies accept this without complaint.

Foreword

This book does not replace a comprehensive dive theory textbook, but is a guide to gaining the theoretical knowledge
necessary to pass the exams for the dive courses listed on the
front page. So to speak "dive theory without ballast"! For those
who want to delve deeper into the subject, the market offers many
good and much more comprehensive textbooks. This book is based on the timing of a dive training; that means it starts with the
introductory dive and then builds on the acquired knowledge. In
this book, the male salutation is used to simplify the writing. Of
course that does not mean that only men should dive. There are
even voices in the "diving scene" claiming that women are the
better divers. In view of the often irresponsible willingness to take
risks of my male contemporaries, this is a thesis that I would definitely subscribe to.

Even though ☺

Divers are men who can live and work under water or in non-respirable air.
Divers are men of great muscle power, with healthy organs.
There is no second profession that places as high demands on

physical performance as the profession of the diver requires, not just occasionally. Wearing the almost 100 kg heavy armor outside the water, or the movement of this mass while walking under water, breathing under rapidly changing pressure and, not least, most strenuous work under not always perfect air supply, require athletic muscles, healthy lungs, strong heart and proper functioning of all organs. Divers are men of high spiritual powers, of intellect and impeccable morality. They have to defy such diverse dangers that the highest demands are placed on their presence of mind and observation. To do useful and fast diving work is at the same time the actual art of the diver, which makes his activity valuable. An unflinching sense of duty must drive him to provide the fastest and most effective solution to the task by giving all the powers of his body and mind.

Manual for divers
Hermann Stelzner
Director and Chief engineer of the Drägerwerk
Lübeck ***1931***

It may have been like that in 1931. Today, diving is possible for
anyone. However, health is still an important requirement.

Content

1. The entry or important for your Discover Scuba course!

To show the beginner wether diving is the right sport for him, it is a good idea to start with a „Discover Scuba course“! There you can check if it is the right sport before you sign in to a complete diving course. The physical suitability for the diving sport, which is best proved by a medical certificate of a specialized divers doctor, must not be forgotten either. Your instructor has the right forms for you. If you do not feel well underwater, you should look for another hobby. As hard as it may be.

The ABC equipment (1.1 to 1.3)

In former times the graders are used to need a blackboard, a piece of chalk and a sponge to learn writing and arithmetic. This was the equipment for the „ABC graders“, and this is what the snorkle diver’s equipment is also called.

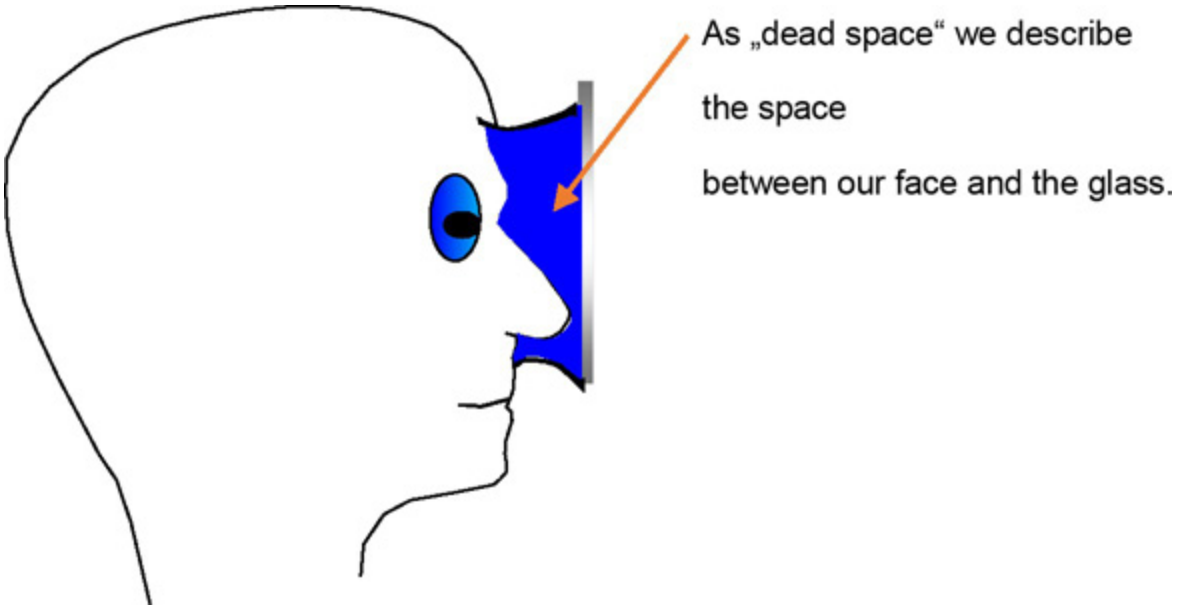
1.1 The diving mask

We need the mask to see clear and sharp under water. The smaller the internal volume of the mask (so called „dead space“) is the easier it is to clear the mask from penetrated water and the wider the angle of view.

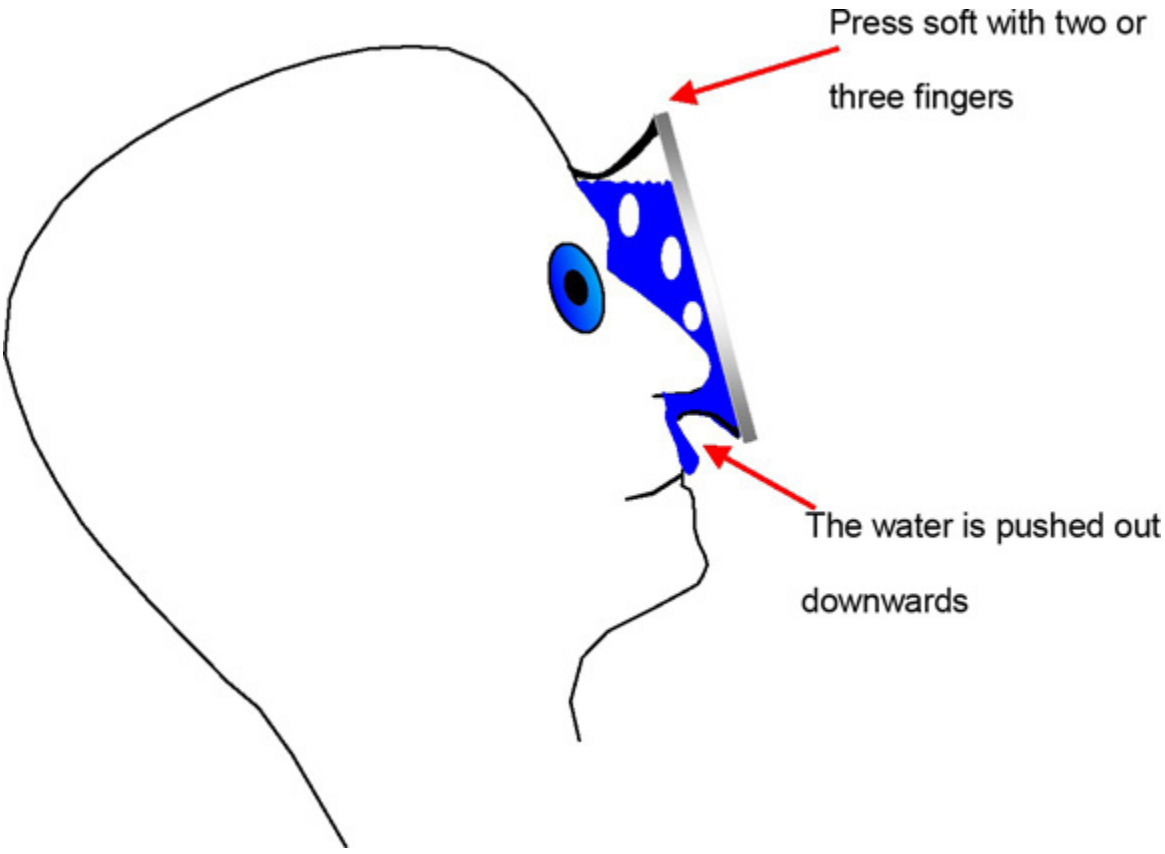
When purchasing your mask, make sure that you can grip your nose well with your thumb and forefinger to make pressure equalization (see page →) (**Nosepocket**). A diving mask consists of the **glasses** (for a lot of masks you can buy optical lenses), the **mask body**, made of silicon or rubber und **the frame**, mostly made of plastic. Masks with additional extensions like valves or snorkels are not recommended and sometimes even dangerous. The mask strap is mostly made of the same material as the mask, silicon or rubber. The individual length of the mask strap will be customized to the head size. This is done by adjusting the two buckles left and right on the frame. Since you usually only adjust the mask band once for yourself, the stable seat is more important than a particularly simple adjustment. Also make sure that the mask glass has a print that shows it is a safety glass. („T“ or Tempered glass or safety glass). Window glass is unsuitable and can lead to loss of sight if it is damaged. When buying, you should

prefer masks made of silicone, because the material is anti-allergic and very UV-stable. A browning of the silicone over the years is harmless. In addition, masks made of rubber are extremely sensitive to suncream, which you should wash from your face anyway before each dive. An absolutely leakproof mask does not exist because there’s no face with the absolute perfect fit. That means that there’s mostly always a little bit of water in your mask. If this water mixes with your sweat and / or suncream, it will result in a "lotion", which burns your eyes worse than any water is able to. To prevent fogging of the mask glass, there are various remedies to buy in the market; but you always have the simplest and "cheapest" anti-fogging agent: your saliva. Spit inside once on each glass and rub the saliva well on the glass. Then rinse the mask briefly in the water and thats all. With new masks, a lubricant film made of silicone oil is often found on the glasses due to the manufacturing process. It must be removed, otherwise the mask will fog permanently, no matter how often you spit into it. To remove this lubricating film, every diver has his own home remedies. I have good experience with liquid silicone remover from the hardware store, but it should also work with toothpaste or Coca Cola. Also the flame of a lighter should work, but since the mask can take damage, you should not try this. Rinse your mask after each dive with fresh water and store the mask cool, dark and dry, then you enjoy it for a long time. Buy your mask in a diving shop or ask the instructor of your confidence to help. A diving specialist dealer or a well-trained instructor knows exactly what you need and you also have a direct contact person for questions about the product.

Dead space of the mask (internal volume)



We have to clear this “dead space” from penetrated water by exhaling out of the nose and pressing the upper rim to the forehead.



For this purpose, we tilt our head slightly backwards, press the upper edge of the mask lightly against the forehead and exhale slowly and continuously through the nose. The water in the mask is now forced downwards out of the mask by the exhaled air. This exercise is a pure diligence exercise and does not necessarily succeed the first time. But practice also makes the master here. I promise you that there are many dives in your life, after which you cannot even say if and how often you have cleared the mask during the dive, that's because it becomes routine over time. There is not a “too much” air blown in as the surplus air escapes through the seals of the mask and the mask gently lays on your face again. This ensures that the internal pressure of the mask is equal to the external pressure. Then you have a clear view again. If you want, you can also have a look at the exercise if you have a QR code reader installed on your mobile. You can get this app for free via the Google Shop or in the Apple App Store. Using IOS, you only need to open the camera app and point the lens at the QR code. I would like to point out that these are photos that were taken in summer in the Baltic Sea near Kiel and therefore, due to the increased algae growth, is to be expected with sometimes poor visibility. But the diving does not always take place in the pool or in the crystal clear water. Naturally, it is not necessary to "clear" the hood in order to restore tightness if the mask has not been removed completely, as in the film.

Seeing under water

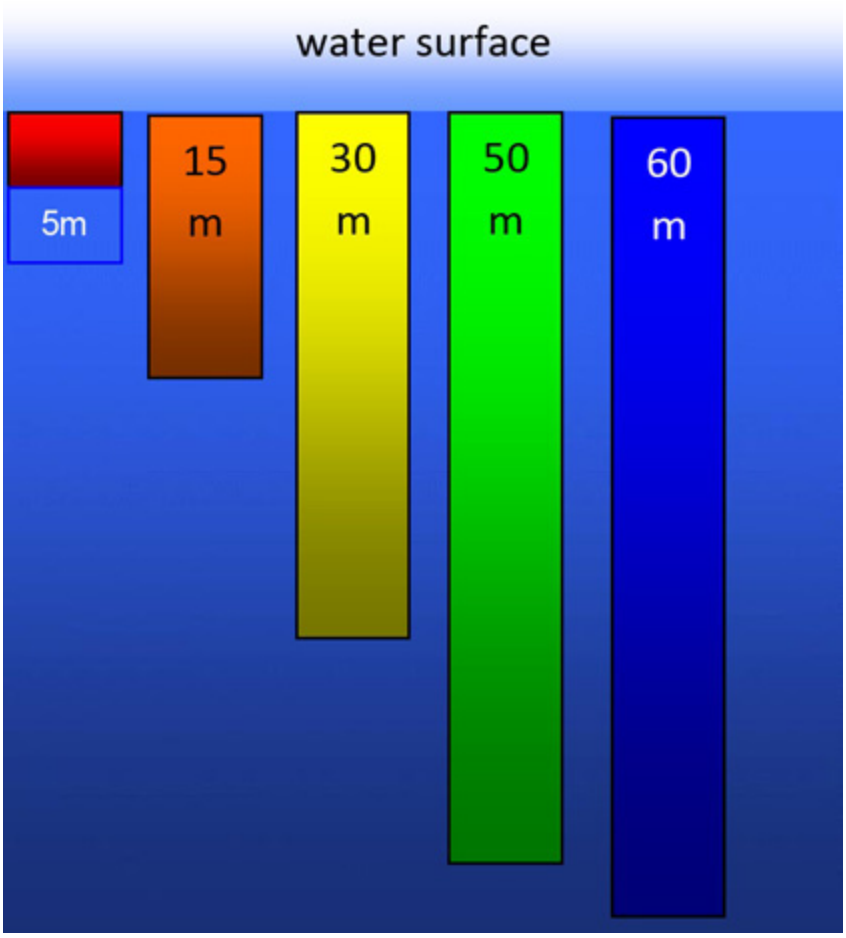
1/3 bigger and 1/4 nearer

Which brings us to “seeing“! Seeing under water is not the same as seeing over water. Apart from the fact that the visibility under water is usually not as good as in air anyway, as there are always suspended solids in the water, which affect the clarity of the water. Due to the seasonal algae bloom or whirled up sediment (sand or similar), the visibility may deteriorate considerably. Due to the different refractive indices of air and water (1: 1.33), we see everything under water 1/3 larger and 1/4 closer than it actually is. Just take it as nature has given, when diving itself has almost no influence. There is even more influence of the water's ability to filter out the light of its wavelength.

Colors under water

In the order **red, orange, yellow, green, blue and purple** the colors are no longer perceived with increasing depth, because the "white" light of the surface, which is composed of the individual spectral colors of the light, is filtered out on the way in the depth according to the wavelength of the individual colors. In practice, this means that the colors (reds and yellows), which still have signal effect on the water surface, lose their signal effect under water after a few meters. In order to be able to recognize the colors then, all you need is a diving torch, which contains all the spectral colors with its white light. Illuminate the objects and then everything is back in color as usual. This feature of the water is also the reason why when photographing or filming under water necessarily a corresponding lighting should be used. Thus, according to the following drawing, the colors are so strongly deprived of water already at the specified depths, that they can no longer be clearly identified. From about 60 meters, all colors are filtered out so far that a recognition of the color blue is no longer possible.

Sequence of color absorption in the water!



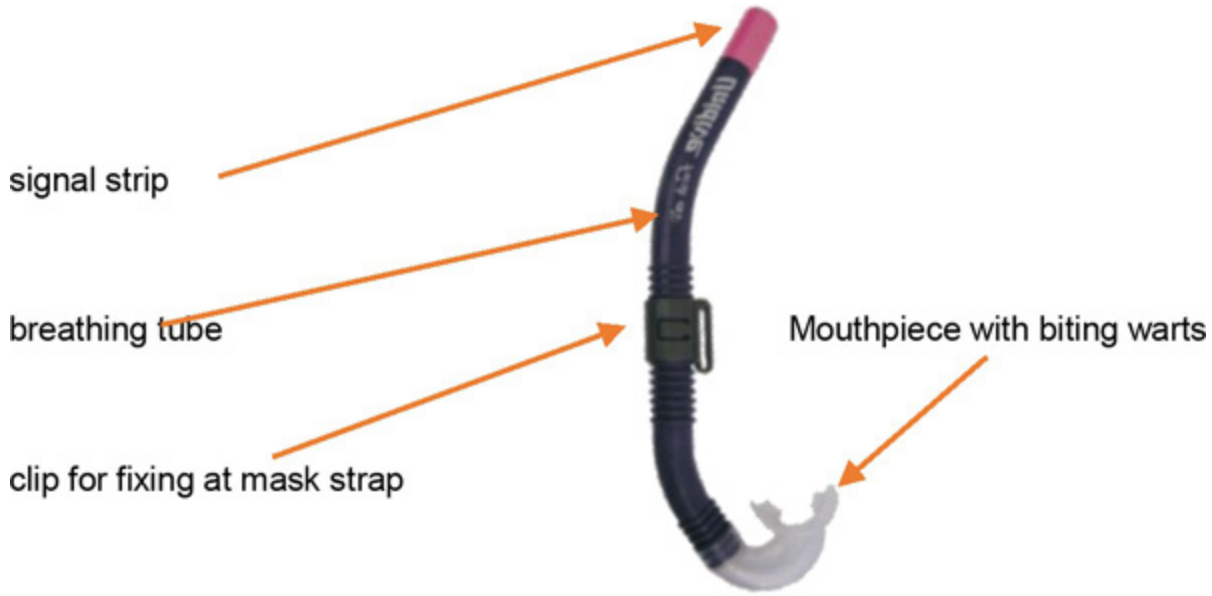
Hearing under water

Even underwater listening is different to listening in the air. The sound, that is the noise, spreads over water at a speed of about **340 meters per second**. The denser the medium in which the sound is transmitted, the higher the speed of sound. In the water, we expect a speed of sound of about 1480 meters per second. So the sound spreads under water about 4.3 times as fast as in the air. Since our hearing system is designed for the speed of sound in the air, we cannot pinpoint a potential sound source, a boat or a dive

partner who wants to attract attention underwater. We hear the sound, but we do not know exactly where it comes from.

Noise, which is produced above the water surface, is barely noticeable under water, as the water surface reflects a large part of the sound. However, we perceive the engine noise of boats as very loud, as this sound is transmitted directly to the surrounding water via the boat hull. Thus, with noises that could come from boats or ships, only emerge when an endangering is no longer given. Keep in mind that the engine noise can be quieter even if the operator only reduces the engine speed. Of course, you must also pay attention to watercraft that make no or little noise, such as sailboats, surfers or rowboats. It is still safest if you emerge in the immediate vicinity of buoys, bridge piers or anchored watercraft. Make sure you pay attention to a possibly rotating propeller. Injuries that you can get when touching a rotating propeller are very serious.

1.2 The snorkel

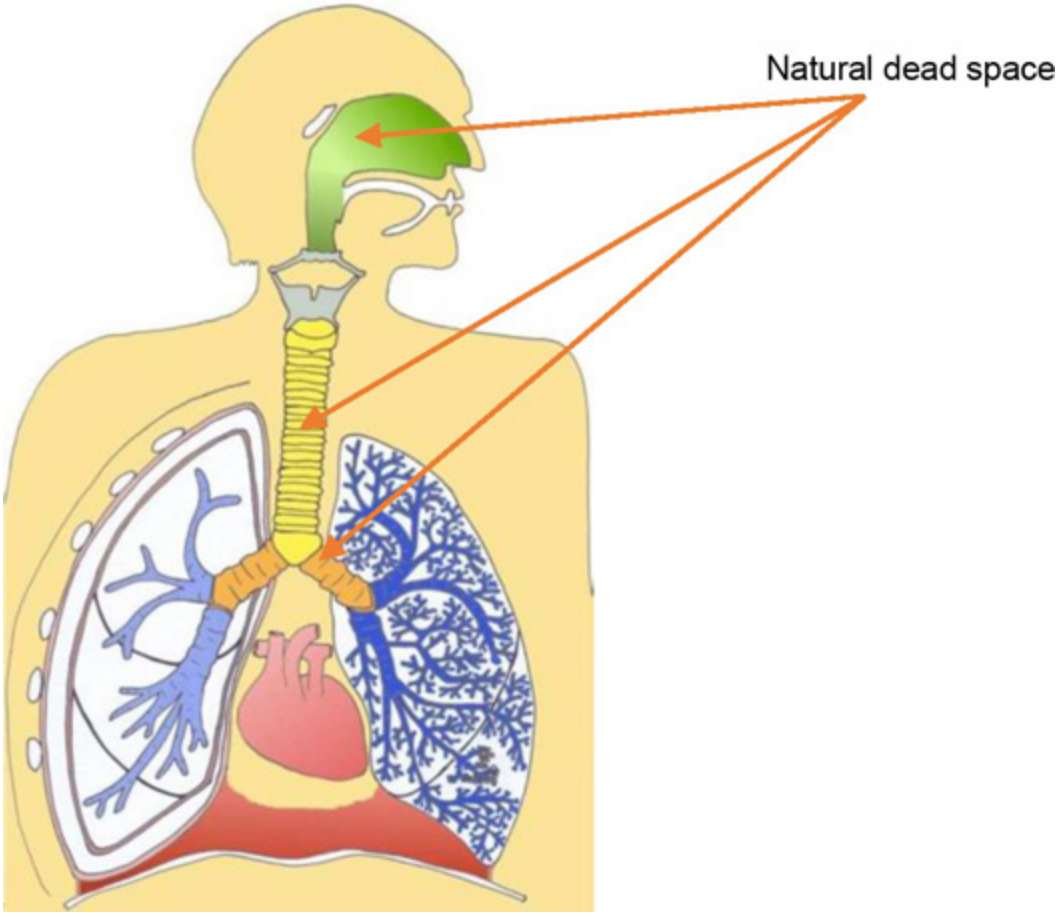


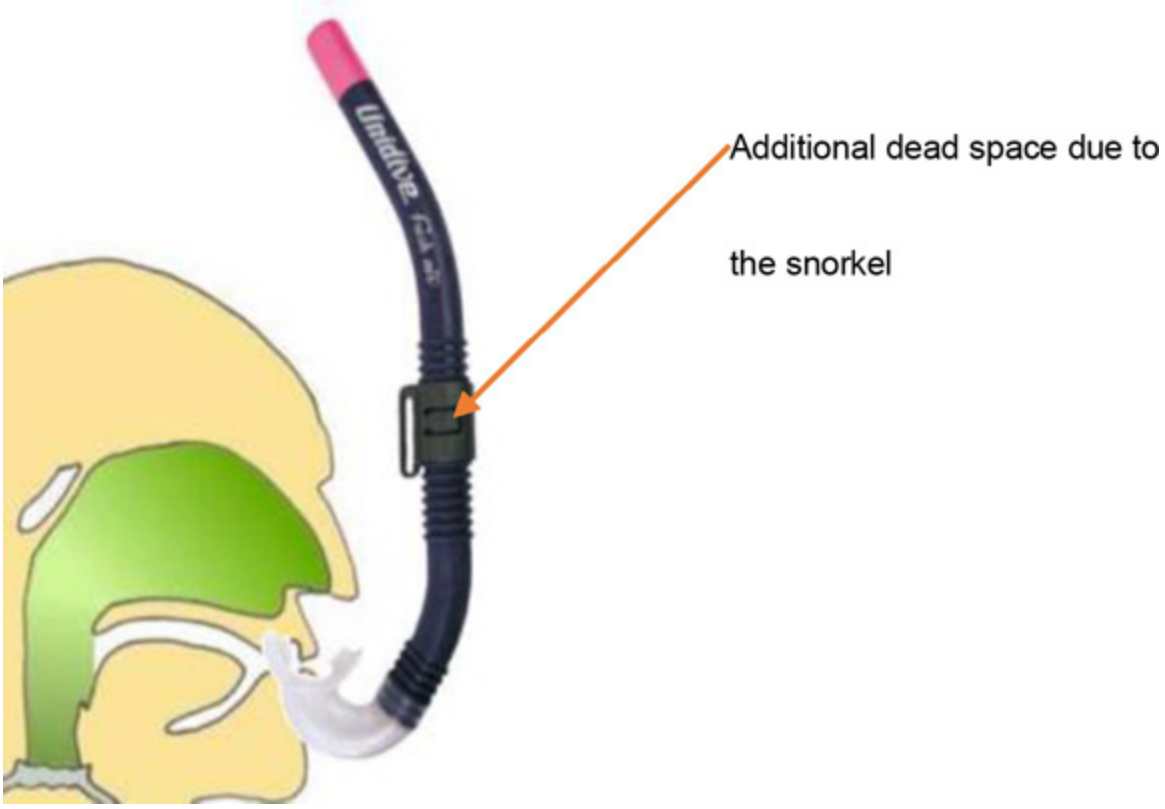
The snorkel is a tube that moves our breathing opening, in this case the mouth, to the back of the head, so that we can lay relaxed on the water surface and can study the fish. Normally we breathe through the nose, but as we use a diving mask to be able to see underwater, this breathing opening is denied us when diving.

What applies to the mask, also applies to the snorkel, if possible without any attachments. It consists of a rubber or plastic tube, a mouthpiece with biting warts (mostly silicone), a rubber or a clip to attach it to the mask strap (not essential, can also be put under the mask strap) and the signal strip at the top of the snorkel (should be signal red to signal to other water sportsmen that someone is snorkeling here). Some snorkels today have a valve at the bottom of the arch. This should drain the water to the water level and make it easier to blow it out (works very well in most cases), but represents a possible source of error if the valve does not close properly due to pollution, so a "matter of taste". **The snorkel for adults should never be longer than 35 cm and the inside diameter must not exceed 25 mm; for children, the dimensions are 30 cm in length and 18 mm in diameter.** An extension of the snorkel and / or an increase of the inner diameter has serious health consequences. If we extend the snorkel or use a longer tube to "snorkel deeper", we can harm our body massively and even die.

We can safely assume that a snorkeler who floats on the water surface is quite relaxed at this moment. Through this relaxation, he breathes little and not very deep in and out. We are talking about a minute ventilation (BMV), which describes the amount of air in liters that "consumes" a diver per minute. Where "consumed" does not really hit the core, but we'll come to that later on. Each breath requires about 0.5 liters of air at rest. Our breathing air is a gas mixture,

consisting of nitrogen (78%), oxygen (21%) and the residual gases (1% carbon dioxide, noble gases and moisture). All we really need is oxygen, but under normal circumstances we do not have a choice. Let us assume that such a snorkel has an internal volume, depending on the length and the diameter of about 0.2 liters. These 0.2 liters are the so-called dead space of the snorkel, so the volume that does not actively participate in the breathing, but this volume we must consider. Humans themselves have already integrated a natural volume of dead space in the airways, namely the bronchi, the trachea and the nasopharynx. These components of the respiratory tract are not compressible, so they are only passively flushed by our breathing air, as well as the dead space of the snorkel.





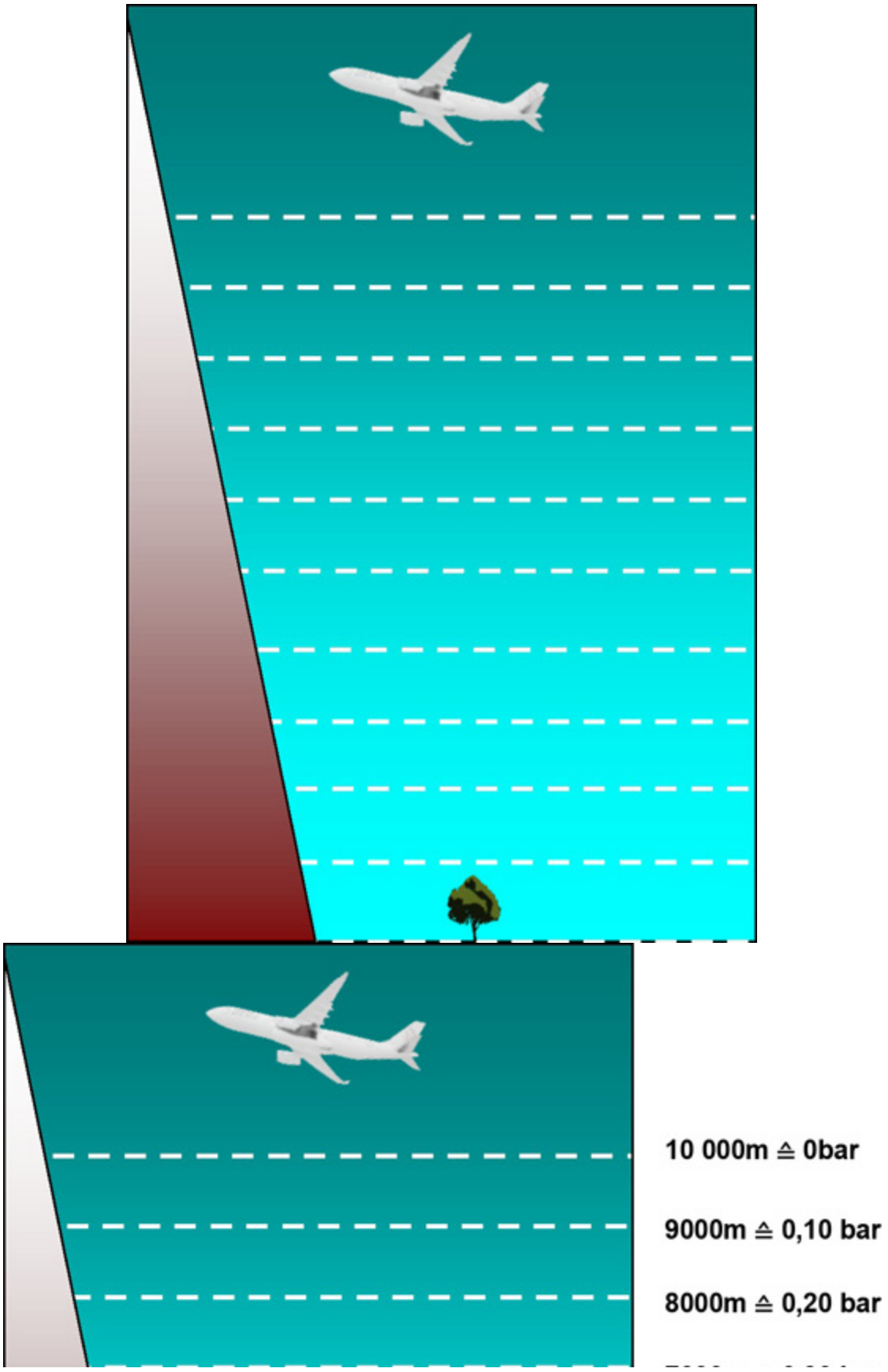
This natural dead space (oral cavity, nasopharynx, trachea and bronchi) is assumed to be approx. 0.15 liters in adults. If we breathe in and out about 0.5 liter at rest, we have 0.2 liters of exhaled air in our snorkel. Our exhaled air has an oxygen content of about 17% as our body converts 4% to carbon dioxide. This means that with the next breath we already breathe in a lower oxygen content than with the first breath. Thus, the oxygen content in our inhaled air continuously drops, and just as with yawning, the body gains the oxygen it needs through occasional deeper breaths. However, if our snorkel is so bulky in diameter and / or length that we breathe in almost all of our exhaled air again, there is a relatively short supply of oxygen to the brain and the risk of fainting increases rapidly. And those who pass out in the water either have an attentive partner by their side or are quite unlucky.

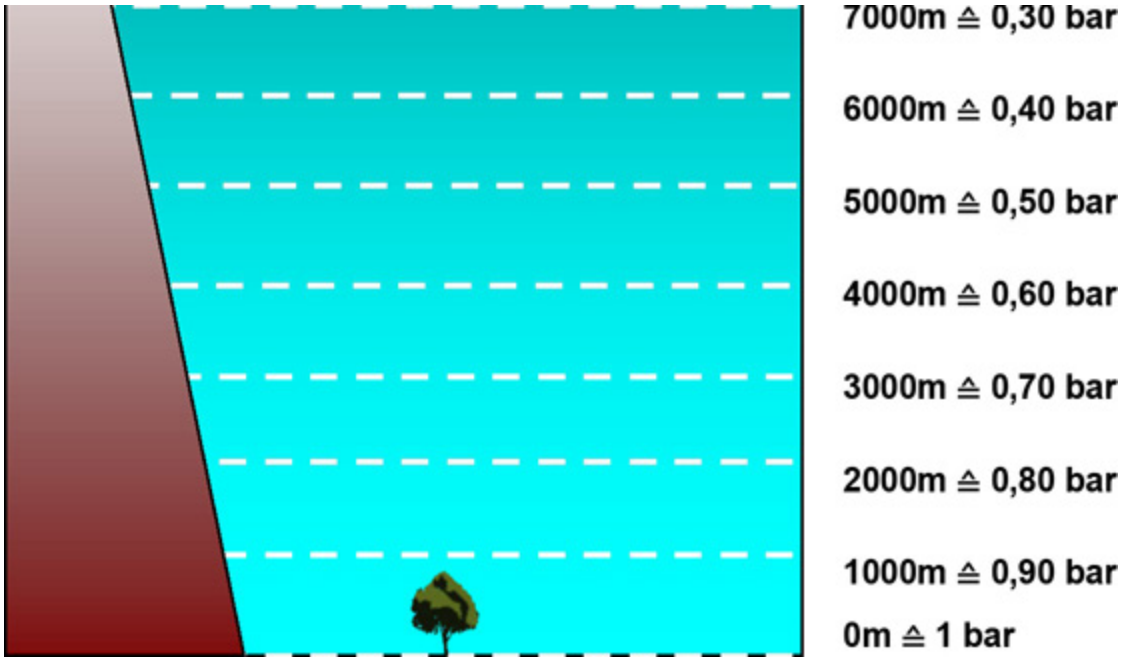
This breathing in and out of used air is called pendulum or dead space breathing and this is absolutely to be avoided.

The second dangerous aspect, the too great length of the snorkel, is also to be considered, even if this aspect is more of a hypothetical nature: for anyone who has ever attempted to breathe through a garden hose has usually been cured. Again, assume that the snorkeler has extended his snorkel to one meter to get closer to the fish. Quite apart from the fact that the snorkeler will now have great problems without a weight belt and with (still) filled lung in one meter of water depth. Now it's getting physically. **The air pressure at the sea surface is according to physical definition 101325 Pa = 101.325 kPa = 1013.25 hPa ≈ 1 bar.**

Pa stands for Pascal and is a unit of pressure, named after the French scientist Blaise Pascal. A Pascal is the force that a Newton exerts over an area of one square meter. Ten Newton is the force that causes about 1 kilogram. Do not worry, it will not get worse, but you need to know how the different pressures affect your body. Namely the normal atmospheric pressure and the newly added hydrostatic pressure, the pressure exerted by the water.

Atmospheric pressure (air pressure)

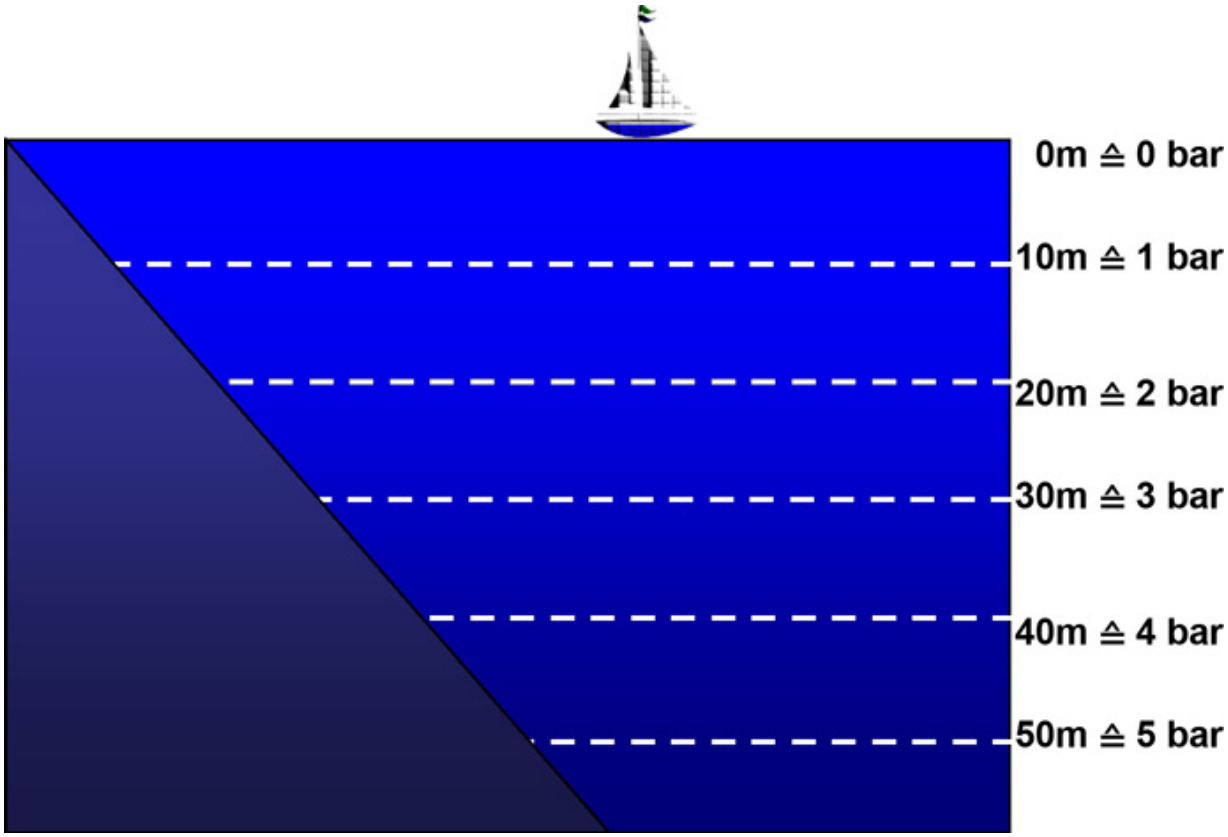

10 000m ≙ 0bar
9000m ≙ 0,10 bar
8000m ≙ 0,20 bar



One liter of air weighs 1.29 grams, so it is not, as often assumed, without weight. The total amount of air, that is the so-called atmosphere that weighs on us, exerts a pressure of about 1.0 bar at sea level, which results from the fact that the air, as well as everything else that is on it, is attracted from the Earth. As the altitude increases, less air is put on us, which means that the pressure on us is reduced. And per 1000 meters height by 0.1 bar, as can be seen from the outline above.

However, water is much heavier than air and we expect 1.0 kg (kilograms) per liter for fresh water and 1.03 kg for one liter of salt water. The higher weight of salt water results from the dissolved minerals that are missing the fresh water.

Hydrostatic pressure (water pressure)



Water has a weight and we assume that, as already mentioned, in fresh water of a weight of 1.0 kg per liter and in salt water of 1.03 kg per liter. In practice, this means that the amount of water that is lying above us and thus weighs on us with increasing depth is getting more and more and thus exerts a steadily increasing pressure on us. Since we are or want to be divers and not meteorologists or physicists, we use the common unit bar for all our calculations. In one meter of water, we have an ambient pressure of 1.1 bar. At the water surface we have an ambient pressure of 1.0 bar. Thus, there is a pressure difference of 0.1 bar. Sounds like little, but has consequences. While the 1.1 bar weighs on our body, the interior of our lungs is connected via the snorkel tube with the surface pressure of 1.0 bar. Thus, our respiratory muscles (diaphragm and rib muscles) must work against this pressure difference, which quickly leads to fatigue of

these muscles. Due to the relative negative pressure that now exists in the lungs, it is almost impossible to inhale air and tissue fluid will increasingly enter the lungs. This is an attempt by the body to compensate the negative pressure. The general term for such processes, caused by pressure differences, is called **barotrauma**. On the one hand, because of the pressure difference, we have problems filling the lungs with fresh air at all, but on the other hand, the body is also working against us, as it additionally reduces the breathable surface of the lungs by the leaked tissue fluid. Thus, there is a lack of oxygen and severe breathing problems, which announce by shortness of breath and cough and can end with a fainting. This form of barotrauma is called lung vacuum barotrauma / lung negative barotrauma or "inner blue coming" and occurs mainly during free diving. And of course with snorkelers whose snorkel cannot be long enough.

1.3 The fins