



FREEDIVER & ADVANCED FREEDIVER



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FREEDIVING

FREEDIVER

ADVANCED FREEDIVER

DEEP FREEDIVER

MASTER FREEDIVER

SNSIREC
FREEDIVING

-40m
-132ft

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The educational material alone does not constitute a complete SNSI Freediver and SNSI Advanced Freediver course. To become a certified freediver it is necessary to complete and pass a full course with an SNSI Freediving Instructor.



CONTENTS

PART 1: FREEDIVER COURSE

CHAPTER 1: FREEDIVING EQUIPMENT

1. Mask	16
Choosing the right mask	
Using the mask	
2. Snorkel	19
Using the snorkel	
3. Fins	20
Choosing your fins	
Using your fins	
4. Protective clothing	24
Choosing your suit	
5. Weight systems	26
The belt	
The weights	
Using the weight system	
6. Buoy and flag	28
7. Watches and depth gauges	29
8. Accessories	30
Dive bag	
Whistle	
Knife	

9. Basic technique	31
Wearing your diving equipment	
Pre-dive check	
Entering the water	
10. Movements	33
11. Your diving buddy	34
12. Exiting the water	35
13. Summary	36

CHAPTER 2: BREATHING AND FREEDIVING

1. Breathing	42
Diaphragmatic breathing	
Thoracic breathing	
Hyperventilation	
2. Training your breathing	45
Dry exercises	
Aquatic exercises	
3. Summary	48



CHAPTER 3: PHYSICS AND PHYSIOLOGY

1. Buoyancy (Archimedes' Principle)	53
Descending underwater	
2. Pressure	57
Boyle's Law	
Equalization techniques	
Surfacing	
3. Gaseous exchange and the breathing reflex	64
4. Gas mixtures and partial pressures	65
Hypoxia and problems linked to breath-hold diving	
Shallow Water Blackout (SWB) and Blackout (BO)	
Loss of Motor Control (LMC)	
Rescue	
5. Freediving and scuba diving	70
6. Temperature	71
7. Vision and hearing	72
8. Summary	74

CHAPTER 4: THE UNDERWATER ENVIRONMENT

1. Temperature and visibility	79
2. Waves and breakers	80
3. Tides and currents	81
4. Underwater life	82
5. Ecology	83
6. Marine organisms	85
Marine plants	
Marine animals	
7. Marine environments	91
Seagrass meadows	
Coral reefs	
8. Human impact	93
Fishing	
Pollution	
Eutrophication	
Invasive species	
Ocean acidification	
9. Personal Responsibility	96
10. Summary	98



PART 2: ADVANCED FREEDIVER COURSE

CHAPTER 5: SAFETY EQUIPMENT

1. The guide rope	106
Weight systems	
Bottom plate	
Knots	
2. Safety lanyard	110
3. Aquatic exercises	111
4. Summary	116

CHAPTER 6: ADVANCED BREATHING

1. Sub-clavicular breathing	121
2. Breathing cycles	123
3. Training your breathing	124
Exercises - Revision	
Diaphragmatic contractions	
Diaphragmatic contraction exercises	
4. Aquatic exercises	128
5. Summary	129

CHAPTER 7: THE PHYSIOLOGY OF BREATHING

1. Ventilation	133
The pulmonary cavities	
The respiratory muscles	
2. Diffusion	136
Henry's Law	
Gaseous exchange	
3. Transportation	139
The two blood circuits	
4. Aquatic exercises	142
5. Summary	143

CHAPTER 8: PHYSIOLOGICAL ADAPTATIONS

1. The diving reflex	148
2. The blood shift	149
Hemoptysis	
Pulmonary edema	
Lung overexpansion	
Diuresis	
3. Aquatic exercises	153
4. Summary	156



WHAT IS THE SNSI FAMILY?

It's a way of being together and taking advantage of a common passion with the sea. Anyone, whether they are a certified diver or not, can share in this opportunity to learn and enjoy time together with others with similar interests. We consider ourselves a family, because our customers, our certified divers and friends comprise a diverse but dedicated group.

We can depend on them to respond enthusiastically to our new ideas and initiatives. They, in turn, have confidence in us and feel free to share in their ideas and feelings. Most importantly, we see ourselves as people and not numbers, regardless of how many certifications or how much experience we have.

Of course, our favorite activities are those that include a tank of air and a body of water to explore, but there's no less enthusiasm when we offer activities such as contests, games and "dry" weekends that include divers and non-divers alike. We are ea-



ger to have the opportunity to learn new theories, and techniques, but equally excited to spend an evening together viewing recent dive trip photos.

Scuba diving is an excellent way to get to know new and different people. Whether you're diving at a familiar dive site, or traveling to a new and unknown

destination, you'll have the opportunity to form more new friendships than you could have ever imagined.

Though we're spread far and wide, we can always connect through our "home base" our central headquarters. Through it you can get information about our latest initiatives; meet hundreds of passionate divers from beginners to experts, and receive advice and encouragement.

You'll feel part of a group; people united by their love and respect of the ocean. This is a family that you'll love to belong to: Our family tree has a branch for everyone!



INTRODUCTION

WHAT IS FREEDIVING?

Just as Icarus dream of flying, for centuries mankind has been fascinated by the mystery and beauty of the deep. Man had always dreamed of reaching the ocean floor and soon these dreams became an objective linked to practical necessities. Our ancestors' history is often closely linked to the ocean. Whether in search of food or for military purposes, humans soon began to find ways of achieving this objective and began to penetrate the depths of the ocean. Without suitable equipment available at the time, freediving became the only way to do this.

The exact origins of freediving are not exactly known. Freedivers have appeared throughout different civilizations at completely different points in history, without any relation between them or knowledge of each other.

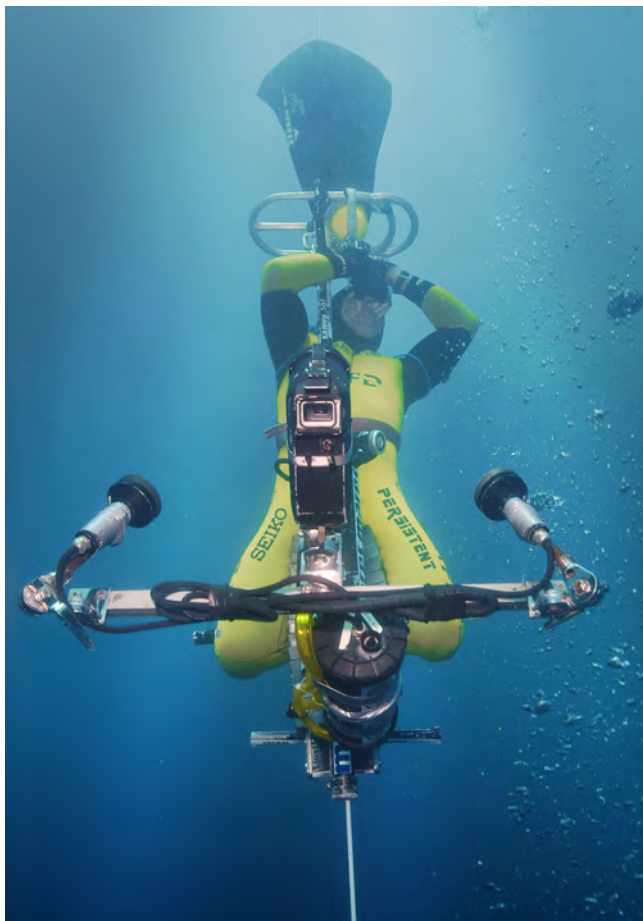
The Greeks and Romans became freedivers in around 4500 B.C., mainly for military purposes. The first freedivers in the Minoan civilization were probably around 1500 B.C., as goblets and vases decorated with sea urchins, lobsters, shells, fish and octopus have been found at archeological sites dating back to ancient times, and archaeologists believe the level of detail of the marine organisms and the representation of their habits indicates that the craftsmen had



observed the creatures in their natural habitat.

In northern Australia, aboriginal paintings depict men swimming with lances. Ceramic vases featuring a diver wearing primitive goggles and holding a fish in each hand have been linked to an ancient tribe known as "Chinchorro" who lived on the coast between Chile and Peru in around the 2nd Century A.D. Many indigenous populations in Polynesia and the Caribbean have practiced freediving to gather shells, fish and to trap lobsters for thousands of years. The Korean Haenyeo and Japanese Ama pearl divers began freediving hundreds of years ago. Ama divers in Japan belong to an organization which was founded in 1800, and still practice this profession using the same techniques as their ancestors. They begin diving at 12 years of age and continue well into their sixties, making an average of 70 or 80 dives a day.





Freedivers have also played a role in military operations, as told by the Greek historian Thucydides. Athenian freedivers attacked Syracuse, cutting a passage through the underwater barriers that the Siracusans had built to block and damage the Greek ships. Roman soldiers also used hollow reeds as a primitive form of snorkel to increase the length of their dives during military operations.

In modern history, during the Italian Renaissance Leonardo Da Vinci (1452-1519) drew the first sketch of a snorkel, mask and fins, revealing his interest in the underwater world. In 1920, Lieutenant Commander Corlieu invented the first prototype that would later become the modern-day fin.

As technology improved and freediving began to be practiced for recreation, the record-breaking period began. In June 1913, the Greek fisherman Yorgos Haggi dived to 77 meters to retrieve the anchor of an Italian naval vessel, making what would now be considered a “No Limits” dive in that he reached the base, held onto a rock and then ascended hand-over-hand back up the cable attached to the rock.

In more recent times, freediving has been rediscovered by some extraordinarily talented people such as Bucher, Falco, Santarelli, Enzo Maiorca and Jacques Mayol, among others. In the 50s and 60s, these masters applied the same techniques that had been used for thousands of years to create a new sport: freediving.



In 1949, the first freediving world record was officially recognized when Raimondo Bucher dived to 30 meters in the Gulf of Naples. Together with a group of other freedivers, Bucher often descended using a weight and then surfaced with fins. Later, the technique developed and freedivers began to surface along a rope to conserve energy.

In the 60s, a new figure, Enzo Maiorca, appeared on the freediving scene, diving to impressive depths that began to draw new fans to the sport. One of these fans was Jacques Mayol, who later broke the record set by Maiorca himself. Mayol was credited as the first freediver to use a sled, a rudimentary version of those currently used in modern freediving, which enabled him to reach unprecedented depths which physiologists had long since thought impossible. Given the reduced physical effort required when using the sled compared



to fins alone, two categories of freediving were created: constant weight apnea and variable weight apnea, described in more detail below.

In recent years, a number of successful athletes have helped freediving to become a very popular sport, and world record holders like Pipin Ferreras, Umberto Pellizzari, Guillaume Néry among the men, and Deborah Andollo, Tanya Streeter and Audrey Mestre among the women, have drawn a great deal of attention to the activity.

However, freediving is not all about records. It is a highly enjoyable and interactive sport that brings you into close contact with the environment, enabling you to rediscover your "lost" connection with the ocean. Freediving is an

exciting sport, and with the right equipment and training anyone can take part, whatever your age and physical condition.

FREEDIVING DISCIPLINES

Freediving differs from *Snorkeling* in various ways. First and foremost, freediving requires not only physical but also mental training, which is probably the major draw for many freedivers and may even be the reason why you chose to enroll on this course. Another factor is the equipment which, although similar to snorkeling and scuba diving equipment in some respects, is designed to meet the specific requirements of this sport. In the next chapter, you will learn the important characteristics of freediving equipment and discover how using this apparatus will help you throughout the course to reach depths that may seem impossible today.

During the course and throughout your future freediving career you will confront different challenges, all related to holding your breath but, as you will soon find out, with different objectives. These different types of apnea, or breath-holding, also represent the disciplines of competitive freediving.

Static apnea: The aim is to hold your breath for as long as possible. Floating on the surface with your face down, you have to hold your breath and try to stay as relaxed as possible. As you aren't allowed to move or descend below the surface, this exercise can be



performed with little or no equipment (for example just the mask). During the *SNSI Freediver* course you will aim to reach the goal of 90 seconds.

Dynamic apnea: The aim is to travel the greatest horizontal distance while holding your breath. This exercise is practiced in shallow water, staying below the surface of the water just enough to prevent the fins from lifting out of the water as you swim. Like the relative competitive discipline, this exercise can be carried out with or without fins. During the SNSI Freediver course you will aim to reach the goal of 25 meters/ 80 feet with fins.





Free Immersion: The aim is to reach the maximum depth possible pulling on a guide rope when descending and surfacing. During the *SNSI Freediver* and *SNSI Advanced Freediver* courses you will practice this technique to prepare yourself for constant weight apnea.

Constant weight: The aim is to swim down to the maximum depth. After performing a correct surface dive, you will swim along a guide rope to the planned depth. Like the relative competitive discipline, this

exercise can be carried out with or without fins. During the *SNSI Freediver* course you will aim to reach the goal of 10 meters/33 feet with fins.

Variable weight: The objective is to reach the maximum depth with the help of an apparatus. The classic form of variable weight apnea is to descend using a weighted sled and return to the surface by finning or pulling your way back up the guide rope. Variable weight apnea has evolved into No Limits apnea, where the descent is made using a weighed sled while the return to the surface is made using flotation devices (solid floats

or inflatables). The use of the descent equipment requires skills and training beyond the scope of this course. This technique is explored in later courses.

During your open water sessions in the *SNSI Freediver* and *SNSI Advanced Freediver* courses, you will be able to combine your constant and dynamic apnea skills to experience close encounters with the marine world, exploring underwater rock faces and coral reefs.

PART 1: FREEDIVER COURSE



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-33ft



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CHAPTER 1

FREEDIVING EQUIPMENT



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To venture into the underwater world, an environment with completely different chemical and physical characteristics to dry land, we need to use equipment designed to enable us to explore this wonderful environment comfortably and safely.

As you will discover during the course, freediving is a predominantly personal experience, and your equipment is part of your own internal journey. As you develop your skills and the *feeling* of being in the water, you will learn how important it is to be at one with your equipment.

At the end of this course you will be able to take a deep breath and immerse yourself under water, where

the only thing you will feel is the beating of your own heart. You will reach the specified depth using your swim fins in broad strokes, transferring power into the fins as though they are an extension of your legs. Instinctively, you will breathe out inside your mask to equalize the pressure with such an automatic reflex that it will feel as though you've been doing it your whole life. This is why the equipment you take with you under water needs to be designed for freediving, with the right comfort. By studying this chapter and the invaluable pointers from your SNSI Freediving Instructor, you will learn how to choose the right freediving equipment.





Remember that having the right diving equipment which is perfectly adapted to your physical shape and condition is one of the most important aspects to maximizing your performance and potential as a freediver.

MASK

One of the goals of freediving is to explore the natural beauty of the underwater world. The human eye is adapted to enable us to see through air and doesn't allow us to see underwater. To be able to see properly under the water, we need to create an air space in front of our eyes. The mask enables us to have an air pocket in front of our eyes and so allows us to see clearly when we are underwater.

There are various models of masks to choose from, but there are several essential features all masks have in common.

Masks should:

- contain the nose pocket (unlike swimming goggles). This enables you to exhale a little through the mask to equalize the pressure and prevent it from pressing against your face which can cause pain or injury to the eyes. Such, swimming goggles aren't suitable for freediving because unlike with a mask, the pressure can't be equalized. As a point of interest, some athletes use swimming goggles and a nose clip when performing static and dynamic apnea (which don't involve

descending to any depth) for convenience and to reduce water resistance, but remember never to use swimming goggles when descending even just a couple of meters under the water.

- have a nose pocket which enables the nose to be pinched easily between your thumb and index finger to equalize pressure;
- have tempered glass lenses to prevent eye and facial injuries in case of breakages (as well as to prevent foot injuries if anyone accidentally steps on them);
- have a comfortable skirt made of rubber or silicone, which forms a water-tight seal when worn;
- have a bezel in stainless steel, plastic or another non-corrosive material that holds the lens or lenses and the skirt of the mask together;
- have an easily adjustable silicone or rubber strap.

The mask may have a single front lens or two lenses set side by side at the same level. The optical characteristics of the mask can also be modified, either by replacing the original lenses with corrective lenses made to suit the diver's vision, or by bonding two prescription lenses to the inside of the single lens.

The most important characteristic of a freediving mask is the internal air volume. Freediving masks are low-volume. As you will learn in the next chapter, descending underwater increases the pressure and the mask needs to be able to compensate for this; as such,

the lower the volume of air within the mask, the easier this equalization becomes. Remember that when you freedive, you can only use the air in your own lungs to equalize the mask, so using less air for this means you will have more time underwater. Moreover, the effort required to equalize the mask increases as you dive deeper, so low-volume masks help to save energy which can then be used for your dive.

Choosing the right mask

Every good dive shop has several different types and models of masks to choose from. As you are taking the SNSI Freediving course, your objective is breath-hold diving, and so the first step when buying your mask is to identify the low-volume models. When

choosing between these, your final choice should depend on how well the mask fits against your face and how easy it is to pinch your nose.

To test a mask before purchasing it, simply place it against your face without fastening the strap behind your head. Now tilt your head slightly backwards and breathe in gently through your nose: the mask should remain in place when you return your head to a vertical position. If the mask falls off, it means that particular model is not suited to the shape of your face.

Once this first test has been passed, put the mask back on and check that you can easily pinch your nose. If it meets all these requirements, then this is the right mask for you.



Types of Masks



Using the mask

To put on your mask, place it against your face then pull the strap behind your head, placing it high on the crown. It should only take light pressure to keep it in place.

All new masks are covered with a thin film that needs to be removed before use to prevent fogging. Wash your new mask well with a nonabrasive degreasing detergent, cleaning the glass and the inside edge thoroughly. Because of the temperature difference between the water and your face, when you immerse in water the mask tends to fog; to avoid this, simply wash the glass of the mask with one of the many specialty products available in most dive shops.

You are now ready to discover the beauty that awaits you in the underwater world.

As explained above, the pressure exerted by the water compresses the air inside your mask: always remember to equalize this by exhaling a little air through your nose, preventing a potentially uncomfortable "mask squeeze".

Emptying the mask. Certain facial movements (such as smiling at the sight of a beautiful fish) may break your mask's seal and allow a little water to enter. To clear it, come to the surface and simply lift your head out of the water and pull the mask away from your face.



SNORKEL

The snorkel is an essential part of your freediving equipment. It allows you to swim or relax on the surface of the water with your face looking down, such as when you are searching for something, enjoying the underwater scenery or simply preparing to dive. In addition, if the ocean surface is a little choppy, the snorkel extends your airway to above your head, helping you to breathe better and stopping water from entering your mouth.

The snorkel is also essential as a safety device, as it allows you to keep your face underwater and thus enables you to constantly monitor your buddy's dives without having to raise your head to breathe.

A good snorkel should have the following characteristics:

- **Diameter:** if the snorkel is too narrow, it will be difficult to breathe; if it is too wide, it will be difficult to expel water. As a rule of thumb, a diameter of around 2 cm (0.75 in) is about right.
- **Length:** if the snorkel is too long, breathing resistance is increased and there is more dead air space, making it difficult to breathe. Your snorkel should extend a few centimeters above your head (1-2 inches maximum) when you are

Types of Snorkels



lying in the water with your face down.

- **Shape:** the snorkel tube should curve inwards slightly to fit to the shape of your head as much as possible to reduce water resistance. It is not recommended to use a snorkel with a corrugated end as some water always remains in the folds and makes breathing difficult.
- The snorkel does not need a purge valve as this significantly increases water resistance.

The snorkel can be worn on the right or left side. If you already have experience diving with a scuba tank, you will probably be used to having it on the left side. However, when freediving it is very important not to fix the snorkel to the mask strap, as otherwise the snorkel would create a lot of water resis-



tance, particularly when it is not in your mouth when diving. The correct snorkel position is between the mask strap and your temple; when you remove the mouthpiece from your mouth when diving, remember to position it below your chin to keep water resistance to a minimum. You must adjust the position of the snorkel so that when the mouthpiece is in your mouth, the top of the snorkel is on the upper part of your head.



Using the snorkel

During your water-based sessions, your SNSI Instructor will explain that it is very important to remove the snorkel from your mouth immediately before or after the start of your dive. This allows you to inhale as soon as you reach the surface. If the snorkel is still in your mouth and you encounter difficulties, you run the risk of inhaling the water held in the tube.

Emptying the snorkel. It is good practice to learn how to empty your snorkel. If the sea is a bit choppy when you are swimming on the surface or watching your buddy dive, water may enter the snorkel. To empty it, simply blow hard into the mouthpiece. On your next inhalation, breathe in carefully to avoid inhaling any water still in the tube.

FINS

Fins are used to provide a larger surface area so that the leg muscles can propel your body through the water in a more efficient way. As such, they allow you to move in the water with the minimum amount of energy possible, allowing you to improve your performance.

There are two basic types of fins: open-heel and closed-heel, also known as “full-foot”. Full-foot fins are best for freediving.

Open-heel fins are fastened with a strap and are usually worn with rigid sole boots which increase the

mass of the fin and create more water resistance. Moreover, the spaces between the fin, shoe and strap are counterproductive in terms of efficiency and transferring energy from the leg muscles to the fin blade.

In contrast, full-foot fins enclose the whole foot, preventing it from moving away from the blade and facilitating more efficient propulsion while reducing the loss of kinetic energy.

The blades on freediving fins are usually very long and narrow to facilitate broad and slow strokes, whereas short, wide fins require a high frequency of strokes to be productive and thus require more muscular effort resulting in the excessive use of energy.

When choosing your swim fins, you will need to consider the environmental conditions of your dives and your own physical strength. If you are diving in cold water environments, you will need to use Neoprene boots to avoid excessive heat loss during your open water sessions. Consequently, your full-foot fin will need to be larger to accom-

modate the thickness of your chosen boots. The fin blade can make a big difference in terms of performance, but there is no single 'best' blade for every diver. Size and rigidity are two important factors to consider. The longer and more rigid the blade, the more propulsion you will get per fin cycle. However, if the blade is too long or rigid for a particular diver's strength or skill, the movement will be tiring and may cause cramps and discomfort. As your strength and swimming abilities improve, you will be able to increase the size and rigidity of your fins accordingly.

Choosing your fins

When worn correctly, your fins should remain sealed around your feet. The foot pocket should be comfortable, without exerting pressure on the foot or allowing it to slide around. Toes should not be cramped and the foot pocket must not limit circulation. Bear in mind that over-

large fins can cause blisters, while excessively narrow fins may result in cramps.



Using your fins

While technological developments have led to new materials, shapes and styles of fin, significantly increasing overall efficiency, diving is still a physical activity and physical fitness and most of all technique are essential. You could have the best fins in the world but if you aren't using the correct finning style, you will never achieve the performance you aspire to.

Using a good technique will enable you to kick powerfully and effectively with the least amount of effort possible, allowing you to use less oxygen and swim for longer without tiring your muscles.

Remember that finning styles vary from person to person and is a characteristic that is unmistakably unique to each diver. Style depends on physical characteristics such as height and leg length as well as the diver's physical fitness.

There are two main finning styles that are commonly used when freediving:

1) *The flutter kick.* For this kick, the legs are used alternately, with one leg

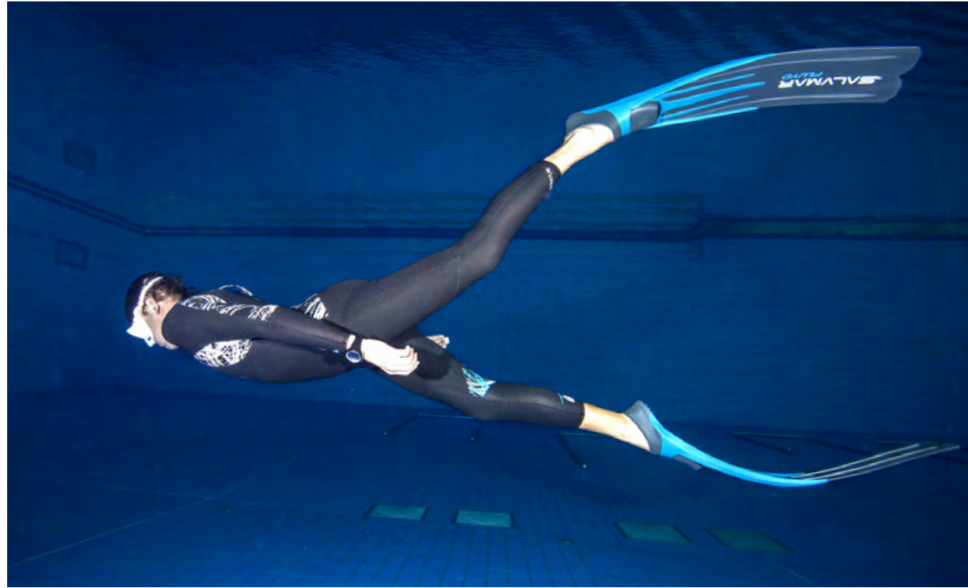
coming up as the other goes down. The movement should begin at the hip and is transferred all the way down the leg to the tip of the fin. As you gain experience, you will feel how the energy of your movements flows all the way down your leg and into the fin blade. The flutter kick is made up of two distinct movements: a pushing motion and a recovery motion. The first movement is when the leg pushes down, while the recovery phase is when the leg is brought back up. It is very important to keep your legs straight and not bend the knees during both phases of the kick. Remember not to flex your ankle, instead keeping it outstretched with toes pointed in the so-called 'ballerina' position. If you flex your ankles, you will let water "escape" from behind the fin blade. The recovery phase is an active propulsion movement that affects your progression and balance. If your recovery motion is less powerful than your pushing motion, you will propel yourself towards the surface. How wide your kick is largely depends on your physical shape; usually, the maximum dis-



tance between your knees should be no greater than the width of your shoulders. Try to make slow, wide kicks and concentrate on staying under the water; at no point should any part of your body come out of water, as this wastes energy by moving your fins without displacing any water. There are two possible arm positions. You can swim with your arms extended alongside your body or stretched out in front; in the latter position, keep the palm of one hand over the back of the other with the

elbows tucked in. Also tuck your chin into your chest, as this enables you to use less oxygen as your neck and shoulder muscles are relaxed, and offers a more hydrodynamic pose. Finally, be careful not to roll your shoulders too much. Just like when you run or walk, when we move a leg forward the opposite shoulder also moves forward. This movement also happens underwater but try to reduce it as much as possible to avoid losing your hydrodynamic position.

2) *The dolphin kick.* Some divers use the dolphin

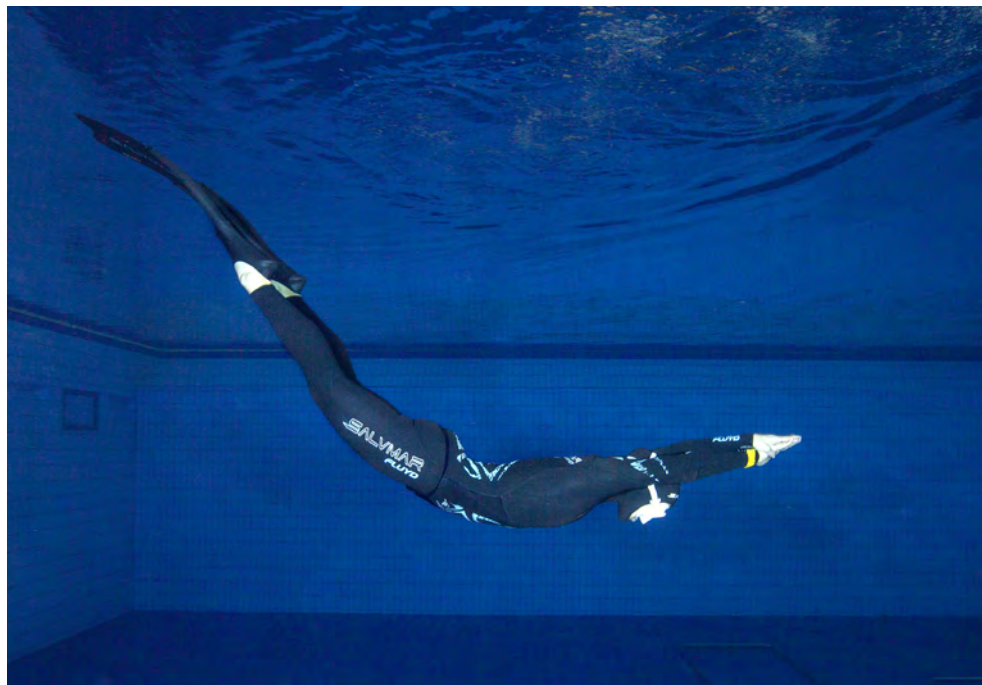


kick, keeping the legs together and making an undulating motion that mimics how dolphins swim. This finning style is predominantly used in conjunction with a monofin, a particular piece of equipment that you will encounter as you progress onto more advanced courses. The dolphin kick is also generally preferred by women, who have greater pelvic flexibility and stronger lower legs than men. These female characteristics can often make the dolphin kick more efficient than the flutter kick. Using the same arm position used





in the flutter kick, swim with your arms stretched out in front, with the palm of one hand placed over the back of the other and tucking the elbows in. For a correct execution of the dolphin kick, begin the undulating movement at the chest. The arms, shoulders and especially head should not move at any point during the dolphin kick. If they do, you will begin to swim in a wavy line, descending and ascending with each movement and traveling much further than the true horizontal line. After bringing your chest downwards, complete the undulating movement along your whole body, lowering the torso, pelvis, thighs and finally the ankles and fins. As for the flutter kick, be careful not to bend the knees too much. The dolphin kick also involves a recovery movement that helps to bring the body back into the horizontal position, working the muscles in your back and the backs of your thighs.



PROTECTIVE CLOTHING

Given that water absorbs heat 25 times faster than air, even apparently warm water can quickly lower your body temperature. During your open water sessions, you will need to protect your body from excessive heat loss.

The protective clothing used for this purpose are



called exposure suits and there are various kinds with different characteristics. For freediving, we recommend wearing a Neoprene wetsuit. The “wet” part of the term refers to a thin layer of water that stays between your skin and the inside of the suit, which absorbs body heat and warms up. If the suit is the right size, the water within the suit stays largely the same and is not replaced with fresh water, meaning heat is lost very slowly and the body can stay warmer for longer. Neoprene is a synthetic rubber that contains tiny air bubbles that help to insulate the diver’s body. These micro bubbles are also important from a safety point of view as they increase the diver’s buoyancy. As such, the suit is an essential piece of freediving kit notwithstanding the water temperature.

Depending on the conditions of your diving environment, you can choose from a range of different suits offering different thicknesses and shapes. Thickness can range between 0.5 and 7 millimeters. The thicker the suit, the higher the level of thermal protection, although this comes at the expense of the suit’s flexibility and therefore ease of movement.

There are different types of suits:

- *One piece with a rear zip:* This model is used in warm water as the rear zip drastically increases water flow within the suit.
- *Two piece without zip:* These are the most commonly used wet suits for freediving. The lower half is usually available as salopettes or





high-waisted trousers. High-waisted trousers have the advantage of improving your breathing ability, especially with thick Neoprene. The top usually features an integrated hood that significantly reduces the amount of water that can get in down the back and protects the head, which is one of the parts of the body most prone to heat loss.

Choosing your suit

It is very important to choose a suit that is comfortable and fits your body perfectly without squeezing or crushing you, as this can limit your movement and breathing. Make sure there is no loose material

under the armpits, on the elbows or at the crotch. The suit should fit quite snugly around the neck, wrists, waist and ankles to prevent water from entering, but not so tight that it prevents blood from circulating or causes discomfort. Be very careful to make sure that the part around your neck is not too tight as compression of the carotid arteries can result in feelings of panic, claustrophobia, vertigo and even cause you to lose consciousness.

Swim socks and gloves are useful accessories to help increase thermal protection.

WEIGHT SYSTEMS

As you will learn in greater detail in the next chapter, your body normally floats on the water surface without too much difficulty. When you use a wetsuit, your buoyancy will increase. You must compensate for this buoyancy by wearing a weight system, which will help you dive without too much effort. For freediving, the best weight system is comprised of a belt and lead weights. The number of weights required differs from person to person, depending on the diving environment (swimming pool, fresh water, different seas) and the type of suit and thermal protection accessories.



The belt

The belt can be made of Nylon fabric or rubber. Rubber is preferable, as this adapts to the fit of the suit and stays flush to your body when diving. There are also various belts on the market that feature pouches or pockets for storing and carrying weights. However, these are not suitable for freediving as they are much bulkier than traditional belts and weights may fall out of the pockets when descending with your head upside down. The belt buckle can be plastic or steel. Again, steel is preferable as this is stronger and more durable.

The most important characteristic of the belt is the quick-release buckle. In an emergency, the diver can simply overcome difficult situations when returning to or at the surface by removing the weight belt. The weight belt also helps to prevent Shallow Water Blackout (SWB - this will be discussed later in the manual), as well as drowning on the surface or during the ascent. You will learn how to avoid both of these situations by following the training given in this course and

the tips from your SNSI Instructor, but in the unlikely event that it does happen, the weight belt must be released as soon as possible.

The weights

Lead weights come in different shapes and sizes, usually ranging from 250 grams/0.5 pounds to over 3 kilograms/6 pounds each. For freediving, 1 kg/2 pounds weights are recommended; these are relatively small and improve hydrodynamics, as well as distribute the weight evenly around your waist to enable correct balance throughout the dive. Some weights are coated with colored plastic; these are visually attractive and although slightly more expensive, have the added benefit of causing less damage if dropped on the bottom of a swimming pool or the deck of a boat, as well as causing less environmental damage than would otherwise result from the lead degrading over time.

Using the weight system

It is important to ensure that the weighting system is always hydrodynamic and well-balanced. Large, bulky weights are more likely to snag on the guide rope. Moreover, weights must be evenly distributed across the waist and the sides of the body to improve balance. If you have too much weight on one side, you will be off-balance on that side. Another consideration



is to avoid positioning very heavy weights directly behind your back, as this can cause discomfort and exert pressure on the spine.

Remember to leave some space between the weights and the buckle free so that the belt can be easily unclipped if necessary. Some shops also sell weight keepers, which are inexpensive and handy accessories to help hold the weights in place.

Checking the weight. To check how much weight you need, stay on the surface and put on your snorkel, then curl up, bringing your knees to your chest and wrapping your arms around your legs. With your lungs completely full, in this position you should be able to keep your head out the water, while with empty lungs you should sink below the surface with the tip of the snorkel staying out of the water. If water enters the snorkel then you are too heavy and need to remove some weight from the belt. If your head stays above the water even after exhaling, you are too light and should add some weight. Your SNSI Instructor

will help you to identify the right amount of weight for your physical characteristics and equipment.

BUOY AND FLAG

The buoy is an essential part of your diving kit and is a very important safety tool. It forms an ideal hand-hold when preparing to dive and can also be used as

a support when resting after the dive or if you are experiencing difficulties. As such, the buoy should be the right shape and size to be able to support a diver's weight. You can also attach a dive flag to the buoy for increased visibility. The international signal used to show that divers are in a particular area is the blue and white "Alpha" flag, the first letter in the International Code of Signals; alternatively, a red flag with a diagonal white band is also commonly used. Both signals indicate that there are divers down and that according to international regulations, boats are prohibited from coming within a radius of 100



meters/300 feet from the flag; the diver must remain within a 50 meter/150-foot radius of the flag.

The buoy is attached to the guide rope which will help you and your buddy during the ascent and descent of your dives.



INSTRUMENTS TO MEASURE TIME AND DEPTH

Another essential part of your freediving kit is a timing and depth device. You can use a watch and a depth gauge, a depth gauge watch or a dive computer.

The purpose of the watch is to time the period you spend underwater and to remind you not to exceed your defined limits. It is important to ensure that the watch is water (and therefore pressure) resistant up to the depth you intend to reach. As the name suggests, the depth gauge monitors the diver's depth, while in-



dicating and recording the maximum depth reached on that particular dive. Many manufacturers offer devices that combine watch and depth gauge features.

A dive computer is definitely the best tool for freediving enthusiasts who intend to continue their dive training. The dive computer shows the basic information required for making a safe dive, such as depth, duration of dive and time between dives, as well as providing useful information such as the maximum depth reached during that particular diving session and the water temperature. It can also be connected to a computer, enabling the user to download the information so they can keep track of their performance and plan their future training. Many dive computers also feature depth and duration alarms which can be very useful when training.

We recommend using devices that have been specifically designed for freediving and not the bulkier counterparts used for scuba diving. Streamlined equipment is better for freediving, as less bulky equip-



ment helps to reduce excessive hydrodynamic resistance and the risk of getting tangled in the guide rope.

Regardless of which instrument you choose, you must always know the duration and depth of your dive as this will help you to keep your activity under control and not exceed your limits. You can also monitor the time between dives to stay safely within the safety margins.

ACCESSORIES

Dive bag

Once you have purchased all your high-quality equipment and long freediving fins, you will want to keep it tidy and secure on your

trips. Dive bags are usually made of durable, robust material and are specifically designed to store your high-quality kit. Certain materials may look very similar aesthetically but often deteriorate after various uses, particularly when they get wet with sea water.

Your SNSI Instructor will be able to advise you on the best equipment to buy.



Dive Bag

Whistle

The whistle is used to attract attention in an emergency. You can keep a small whistle attached to your dive buoy.

Knife

The main purpose of a dive knife is to cut lines or the guide rope in the unfortunate case that you become trapped or tangled. In some areas the use of dive knives is prohibited without special permission, so check with the SNSI Diving Center or the local diving center with whom you are diving.

The knife should be made of stainless steel or titanium and have a sheath with a safety lock to prevent it from sliding out accidentally.



BASIC TECHNIQUE

Wearing your diving equipment

So far we've seen the different components of your diving equipment. You're now ready to put them on and embark on your underwater experience.

The equipment should be put on in a logical order, starting with the wetsuit, the weight belt, the mask and snorkel, and finally the swim fins. As fins are difficult and uncomfortable to walk in, as well as easily damaged, these should be the very last things you put on and should only be worn just before you enter the water.

Pre-dive check

Later on in this manual we will discuss in more detail the freediving buddy system, which ensures maximum safety as well as increasing your enjoyment. Before beginning a dive you will spend a few moments checking that your buddy's equipment is all in order. In particular, check that the mask strap is correctly positioned on the nape of the neck and that there is no hair or part of the hood trapped beneath the silicone around the mask. Finally, check that the belt is positioned correctly. The end of the belt should be on the left side





of the body and should not be encumbered in any way so that it can be unclipped easily in an emergency.

Entering the water

How you enter the water depends on where you're diving and your own personal preferences.

- *Entering from the beach.* If entering the water from a beach, carry your fins until the water comes up to your waist then put them on with the help of your buddy. Be careful not to bang the fins against the sea bed as not only will this damage the fins, it might also hurt the marine life.
- *Entering from the poolside or a low ledge.* Sit on the edge with your legs in the water and put on your fins. Now place both hands on one side of your body and use your arms to rotate your body away from the edge and into the water.
- *Entering backwards.* If entering the water from a low ledge or the edge of the boat you can do so backwards. Sit on the edge with your back facing the water and your heels placed on the outside edge then fall backwards, bending at the waist and knees. Your backside should come into contact with the water first.

Remember that the best entry is always the one you find the easiest. Always enter with your mask on your face and your snorkel in your mouth to make sure you can see and breathe.



HOW TO MOVE

As you will discover in the following chapters, different laws of physics come into play during our excursions in the ocean, affecting our balance, our movements and our motion.

It is very important to follow the correct technique right at the beginning of your diving career, learning how to move efficiently and simply to stay on the surface. In particular, you need to understand the difference between the movements that propel your body

through the water (where you should move as much water as possible) and the recovery movements that bring the arms or legs back into the starting position to begin the next stroke (where you should aim to create the least resistance possible).

Arm strokes. Position yourself vertically in the water, taking care to keep your legs perfectly straight and close together. Position your elbows at ninety degrees and tuck them into your chest, keeping the upper part of the arm close to your body and the fore-



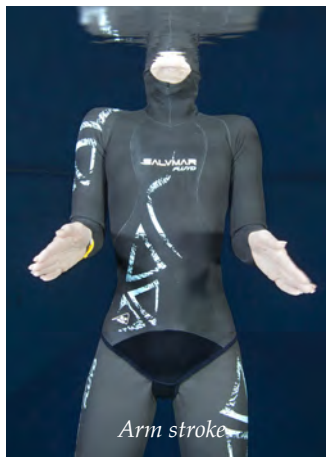
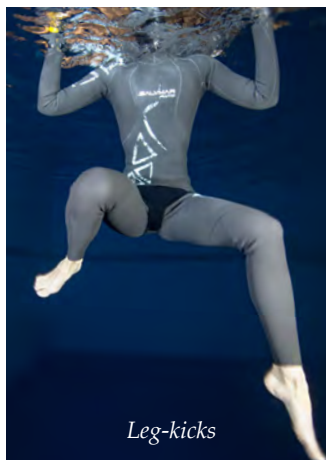
arms turned towards you. Keep your palms facing down and move the fore-arms out and then in, rotating the palm slightly to “capture” as much water as possible. As you move your arms out, rotate the palm outwards, then as they come back in, rotate the palm inwards. This technique will allow you to maintain your position perfectly.

Leg-kicks.

- *Frog kick:* From a vertical position, bend your arms and keep your hands out of the water. Move the legs in a frog kick to float. On each kick, remember to flex the ankles and keep the feet at a ninety degree angle to the legs. Be careful not to bob in the water: the water level should always be just below your shoulders.

- *Alternating kick:* From the same position as the previous exercise, alternate moving each leg. Still push inwardly from the outside, so that as one leg pushes and moves in, the other is in the recovery phase and so moves out.

Complete strokes. Make each stroke with the legs and arms at the same time, first with the frog kick and then with the alternating kick.

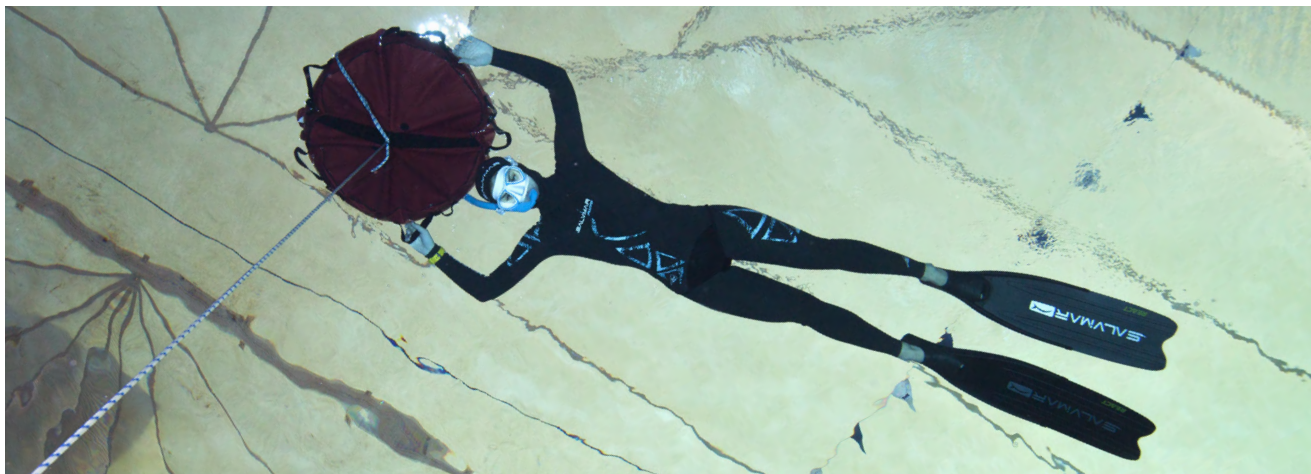


YOUR DIVING BUDDY

Freediving should always be practiced in pairs. Diving with a buddy is an essential safety practice and, as you will discover, brings an added level of enjoyment to your dives. The procedures are simple and will allow you to freedive in complete safety.

Each buddy dives one at a time, with the second buddy only beginning their dive after the first has physically recovered from the previous dive. This is so the first buddy has regained enough energy to be able to help the second if needed, and so after your buddy returns to the surface, you will have to wait a few minutes before beginning your own dive.

When one of you dives, the other stays on the surface near to the inflatable buoy which is connected to the guide rope. The non-diving buddy should have their mask and snorkel on and be continually focused on their buddy, monitoring their condition, making sure signals are given and watching out for any symptoms of Shallow Water Blackout (SWB) and Loss of Motor Con-



trol (LMC), which are covered in more detail later in this manual.

Agree on the signals you will use to communicate with one another, in particular the signal you intend to use to ask for help. After each dive, upon returning to the surface remember to exchange the OK signal to confirm that the returning buddy is safe and well.

If you notice any problems or see the help signal, you should go underwater to reach your buddy and bring them to the surface.

If you are in a group of three or more divers but are only using one guide rope, agree on buddy pairs so that everyone knows who they should monitor and who to help if needed. Always establish the depth you

intend to reach on each dive with your buddy before diving.

If you don't feel comfortable in offering assistance at the depth your buddy intends to reach, tell them beforehand to prevent any problems.

EXITING THE WATER

Exit from the water in the simplest and safest way possible. If there is an exit ladder, remove your weight belt and your fins beforehand, placing them on the edge or passing them to those helping from the surface. If there is no ladder and the edge is not too high you can remove your belt, place both hands on the



edge and pull yourself up. In both cases, when you are waiting for your buddy to exit from the water, keep a safe distance away so that they don't land on you if they slip. If you have to exit on the beach, take off your fins as soon as the water reaches the height of your waist then walk out.

Rinsing your equipment

Your diving session doesn't end until your equipment is washed and stored in your bag. To keep your equipment in top condition, rinse with fresh water after every use to remove any salt, sand and dirt that may accumulate. After washing your equipment, leave it to dry in a cool, dry place.

SUMMARY

As you have read, understanding your equipment is a fundamental step to achieving the objectives of this course and will improve your performance as you advance in your freediving career. Now that you know what equipment you need and how to use it correctly, you will want to try it in the water! Your SNSI Instructor will accompany you on your first freediving experience in a confined water space, where you can safely put all the basic exercises that will open the doors to your freediving career into practice.



CHAPTER 1 STUDY GUIDE



1. Which material are the mask lenses made of?
 - ☐ Tempered glass.
 - ☐ Plastic.
 - ☐ Glass.
2. Which characteristic indicates that a mask is specifically designed for freediving?
 - ☐ Transparent silicone.
 - ☐ Low volume.
 - ☐ Adjustable strap.
3. Can you use swimming goggles to freedive?
 - ☐ Yes. There is no difference between swimming goggles and a mask.
 - ☐ No. Swimming goggles do not cover the nose.
4. Which side of the mask should you put the snorkel on? How?
 - ☐ Right side. With a proper snorkel keeper.
 - ☐ Left side. With a proper snorkel keeper.
 - ☐ It doesn't matter which side as long as the snorkel is firmly positioned between the strap and the temple.
5. When should you have the snorkel in your mouth?
 - ☐ Always.
 - ☐ Only when you are on the surface.
 - ☐ When you are surfacing.
6. Which kind of fins should you wear when diving?
 - ☐ Open-heel fins.
 - ☐ Full-foot fins.
 - ☐ Any type of fin.

- 7.** How much should the weights used for freediving weigh?
 - ☐ 0.5-1 kg /1-2 lbs to improve hydrodynamics.
 - ☐ 2-3 kg/4-6 lbs so you don't need as many weights on the belt.
 - ☐ It doesn't matter.
- 8.** When the belt is worn with the correct weights, the end of the belt should:
 - ☐ Extend 20-30 cm /8-12 in beyond the buckle.
 - ☐ Extend 3-5 cm/1-3 in beyond the buckle.
 - ☐ Be folded under the belt if it is too long.
- 9.** What is the purpose of the surface buoy?
 - ☐ To make the diver visible to boats.
 - ☐ To offer support when resting on the surface.
 - ☐ Both.
- 10.** The whistle is used to communicate with your buddy if they are too far from the buoy.
 - ☐ True.
 - ☐ False.





CHAPTER 2

BREATHING AND FREEDIVING



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CHAPTER 2



From the moment we are born, we take our breathing for granted. It is a subconscious action, not something we have to think about. Right now, as you are reading this, you're not thinking: "remember to breathe, remember to breathe...". We simply breathe naturally without having to think about it, taking an average of 8-12 breathes a minute, every day, for the rest of our lives.

Obviously when you hold your breath, you can't breathe, and in fact this might be the main reason that you enrolled on this course.

However, as you read the next few pages and follow the exercises, you may be surprised at the

hidden ability that we humans have to extend the length of time we can hold our breath underwater, even managing not to breathe underwater for longer periods than we can on land.

As well as learning how to use the right equipment, you will discover how to conserve energy and move more efficiently; in fact, the most important step you can make to improve your freediving performance is to learn to breathe correctly. In this chapter you will learn that not only is it fundamental that you learn how much to breathe, it is as important to understand how to breathe as well, and this will give you a big boost in performance.



BREATHING

In our everyday lives, when we breathe involuntarily, we only use a small proportion of our lung capacity, around 10-15% which equates to around 0.3-0.5 liters (0.01 - 0.02 ft³). You will come to understand that when it comes to your freediving performance, there is plenty of room for improvement by learning how to breathe correctly.

First of all, we will start by looking at how we can increase the use of our lung capacity.

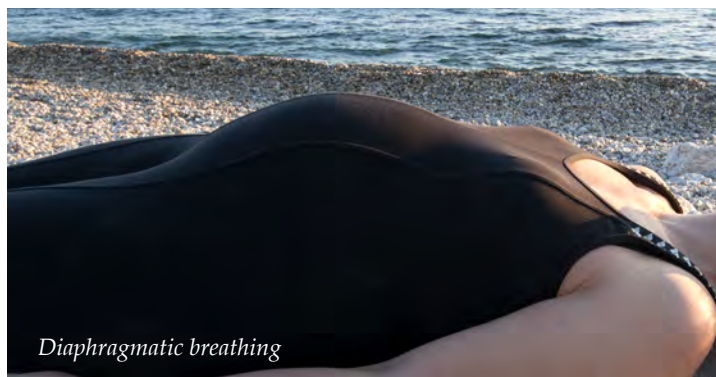
Diaphragmatic breathing

Diaphragmatic breathing is one of the most important steps to attain a correct breathing technique. It maximizes the extraordinary potential of the diaphragm, a dome-shaped muscle located below the lungs which separates them from the abdominal cavity. When the diaphragm contracts, it squeezes the abdominal cavity, which contains many of our internal organs, and pulls the lungs downwards to increase their volume. When it releases, it pushes the lungs back up, so reducing their volume. The diaphragm is one of the main muscles used to achieve a correct breathing technique. This is because its location in the lower part of the lungs enables us to breathe deeply, which lets us inhale air to fill the lower third of the lungs. This part supports

around two thirds of the blood supply to the lungs and facilitates gas exchange; we will cover this in more detail in the next chapter.



Resting diaphragm



Diaphragmatic breathing



Diaphragmatic breathing is a natural breathing method. This is proven by newborn babies, whose abdomens rise and fall without any movement of the chest. However, as we grow up we modify our breathing, developing poor posture and breathing exclusively through our chest (thoracic breathing).

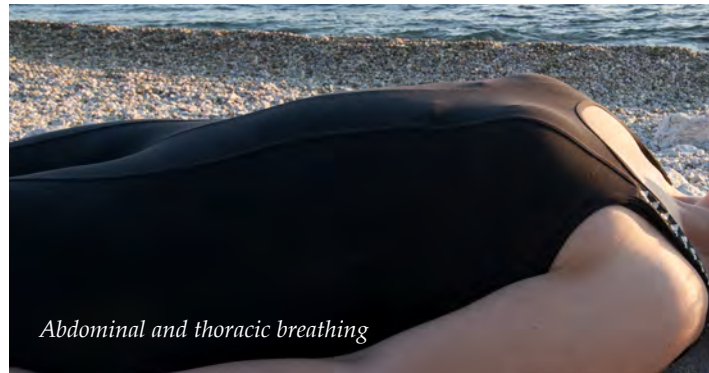
For correct diaphragmatic breathing, we need to push the abdomen muscles outwards and lower the diaphragm at the same time.

Thoracic breathing

Thoracic breathing uses the muscles in the rib cage, namely the intercostal muscles located between the ribs. These muscles allow the lungs to expand outwards and upwards, enabling the inhaled air to enter the lungs. These muscles stimulate the pulmonary stretch receptors, signaling our body that we have inhaled enough air and that our lungs are essentially full. Thoracic breathing causes us to inhale and exhale air only in the upper part of our lungs.

As we mentioned earlier, we know that it is the lower third of our lung capacity that has the greatest potential for gaseous exchange, and so on its own, thoracic breathing is not the most efficient way of breathing.

By inhaling and expanding the rib cage outwards and upwards, we are able to enable thoracic breathing. When we are preparing to dive, we combine abdominal and thoracic breathing.



Breathing cycles

A correct breathing technique suitable for freediving uses both of the breathing methods described above, used in the right order, for the right duration and with the right volume.



Preparatory breathing. Begin with abdominal breathing, inhaling and exhaling a normal volume of air and keeping the abdominal muscles relaxed. During this phase, you are preparing to enable air to flow correctly: you need to relax all the muscles in the body and take the time you need to focus and visualize your final objective. When you return to a normal breathing pattern (for example after a freedive), you will need to spend at least a minute following normal and relaxed breathing cycles solely through the abdomen. This is an essential phase after each freedive to re-establish the right balance of oxygen and carbon dioxide levels in the blood.

Breathing sequence. After doing preparatory breathing for at least a minute, begin the breathing sequence. It is very important to follow these stages in the precise order, beginning with abdominal breathing, proceeding onto thoracic breathing and then following the same order during exhalation, emptying the

lower part of the lungs by the diaphragmatic method then breathing through the chest to empty the central and upper part. It is important to maintain a steady breathing rhythm; each inhalation should last 3-5 seconds, followed by 3-5 seconds of exhalation. You must repeat this procedure for at least two minutes, meaning you will make around 15 - 20 complete breathing cycles.



Final breathing sequences. When you feel ready to hold your breath and start your dive, you must focus fully on your final breathing sequences. Continuing to breathe the same as the previous phase, take a deep breath and inhale as much air as possible, throwing your shoulders back when breathing through the chest to increase the amount of air entering the lungs even more. Pause for a second at the end of the inhalation then exhale all the air in your lungs, forcing the air out slightly, for 6-10 seconds. After only two full breathing sequences, take a final breath, again trying to inhale as much air as possible, and hold your breath to begin your dive.

Hyperventilation

Hyperventilation is a breathing method characterized by a breathing frequency of around 25 breaths per minute. The main objective of hyperventilation is to reduce the amount of carbon dioxide in the body as much as possible. This technique is used by athletes who need to avoid breathlessness as much as possible (boxers, skiers, sprinters).

Hyperventilation lowers the level of carbon dioxide in the blood by extending the time before the urge to breathe kicks in, but does not increase oxygen supply to the cells. This is why hyperventilation is the main cause of blackouts.

We will look at this topic in more detail in the next chapter, but remember **never to hyperventilate before a freedive**.

BREATHING TRAINING

Dry exercises

As we have already mentioned, freediving is a personal challenge based predominantly on your mental attitude, your concentration and your ability to relax. As such, it is effective and indeed good practice to develop and train your breath-hold technique out of the water. You don't need to drive to the pool, get changed, put on your swimsuit and get into the water every time you want to train, you can obtain excellent results by practicing while lying on the couch in your living room. After your SNSI Freediving Instructor has demonstrated the following exercises, you will be encouraged to practice at home, although even here you should always be accompanied by your buddy.

Moreover, starting with dry exercises will help you to perfect your technique. Although your body can adapt perfectly well to the underwater environment, we are nonetheless terrestrial beings and consequently we can better interpret and understand our body's signals out of the water. These exercises will help you to familiarize yourself with the abdominal and diaphragmatic contractions that indicate the first breathing reflex which, as you will discover, is produced from an increase in carbon dioxide levels in the blood. Remember that these signals are a warning from your body to let you know that you need to take another breath. When these signals occur, we have to stop holding our breath.



Important Note: The first time you try these exercises, only do so under the supervision of your SNSI Freediving Instructor. This is safer, and will allow your Instructor to give you immediate feedback and provide you the opportunity to make corrections to your techniques while avoiding bad habits. Afterwards, you can repeat these exercises without your instructor but *always do so with your buddy and never alone.*

Timed apnea. Lie face up in a relaxed position with your feet on the ground and legs bent. Complete one full breathing cycle: preparatory breathing, breathing sequence and final breathing sequence. *Now hold your breath!* Remember, when you feel your diaphragm contract, start breathing again.

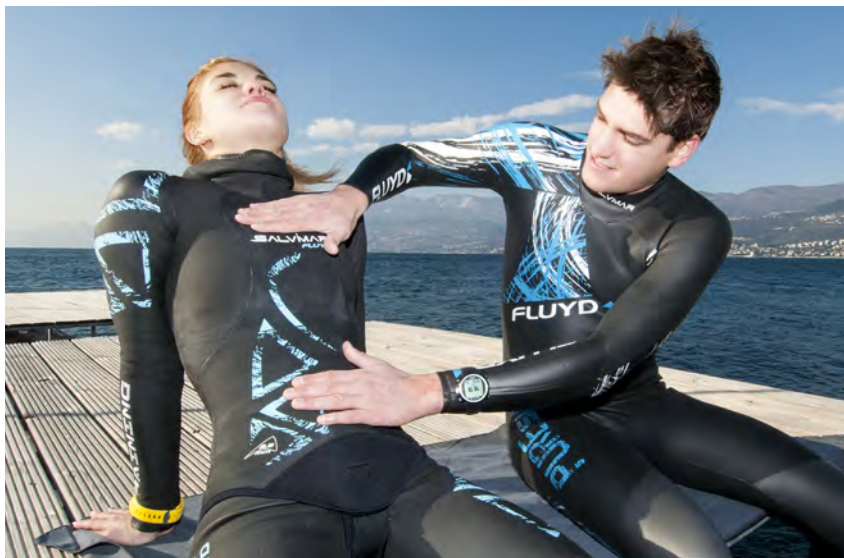
Your instructor will time you to keep track of your performance.

Walking apnea. This is one of the best dry exercises to increase your breath-hold ability. The technique trains your body to work with high levels of carbon dioxide and low levels of oxygen. Sit on a chair in a relaxed position with a straight back. Complete one full breathing cycle: preparatory breathing, breathing sequence and final breathing sequence. *Now hold your breath!* Stand up and walk in a

straight line at a relaxed and slow pace. Try to take steps that are about the same length as your shoulders. Remember, when you feel your diaphragm contract, start breathing again.

Your instructor will count how many steps you manage to make and will make a mark on the floor, so you can see how you improve from one exercise to the next.

Important Note: Allow time between each repetition for your body to recuperate and recover its strength, performing 3-5 minutes of abdominal breathing between each repetition.



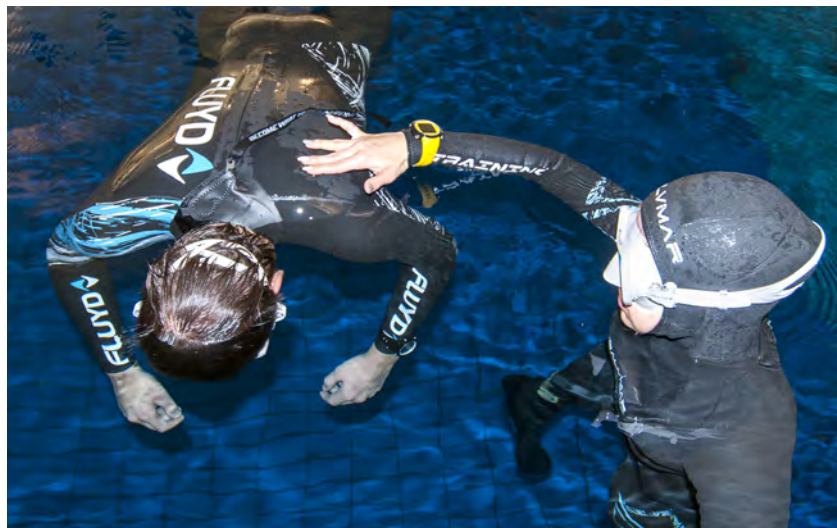
Aquatic exercises

It is now time to apply your breathing techniques in the water to begin to achieve the performance you need to become an SNSI-qualified Freediver and continue your freediving career. As you will see, the aquatic exercises follow the same procedures as on dry land but are applied underwater.

Important Note: The first time you try these exercises, only do so under the supervision of your SNSI Freediving Instructor. This is safer, and will allow your Instructor to give you immediate feedback and provide you the opportunity to make corrections to your techniques while avoiding bad habits. Afterwards, you can repeat these exercises without your instructor but always do so with your buddy and never alone.

Static apnea. From a relaxed position, for example kneeling on the bottom of the pool or leaning your forearms against the side, complete a full breathing cycle: preparatory breathing, breathing sequence and final breathing sequence. **Now hold your breath!** Lie in the water and float face down. If you aren't wearing a wet-suit or this doesn't offer you enough buoyancy, you can use a float under your legs. Try to find a comfortable

position, relaxing your muscles as much as possible. Your buddy will help you during this exercise, so agree a signaling system for safety. For example, your buddy might signal you every 15-30 seconds (depending on the scheduled length of the static apnea; the first few times you try, you will aim for 60 seconds and so your buddy will give a signal every 15 seconds, then once you have more experience and are aiming for 90 seconds, your buddy can signal to you every 30 seconds) and you might respond with a gesture, such as a nod of the head or a hand gesture. One of the most common-



ly used signals is to raise the index finger. Remember, when you feel your diaphragm contract, come back into a vertical position and start breathing again.

Dynamic apnea. Lie in the water and float with your facing down, trying to find a position where you can relax all your muscles. Position yourself near the edge of the pool, facing in the direction of your dynamic apnea. In this position, complete one full breathing cycle: preparatory breathing, breathing sequence and final breathing sequence. **Now hold your breath!** Raise your legs, place your feet on the wall and push away from the edge of the pool. Point your head down and arch your back slightly to descend below the water surface. You can use the flutter kick or dolphin kick for this exercise. Follow the guide rope along the bottom or the

line along the bottom of the pool. Remember, when you feel your diaphragm contract, come up from the water and start breathing again.

Your buddy will follow you from the surface, carrying a flotation device in order to offer you support or assistance if you need it.

SUMMARY

Much like with our brains, when we breathe we usually only use a tiny percentage of our body's extraordinary potential. Now that you have read this chapter, you have the knowledge and skills to increase your capacity and achieve your goals. Remember that success depends on your training and training and willpower.



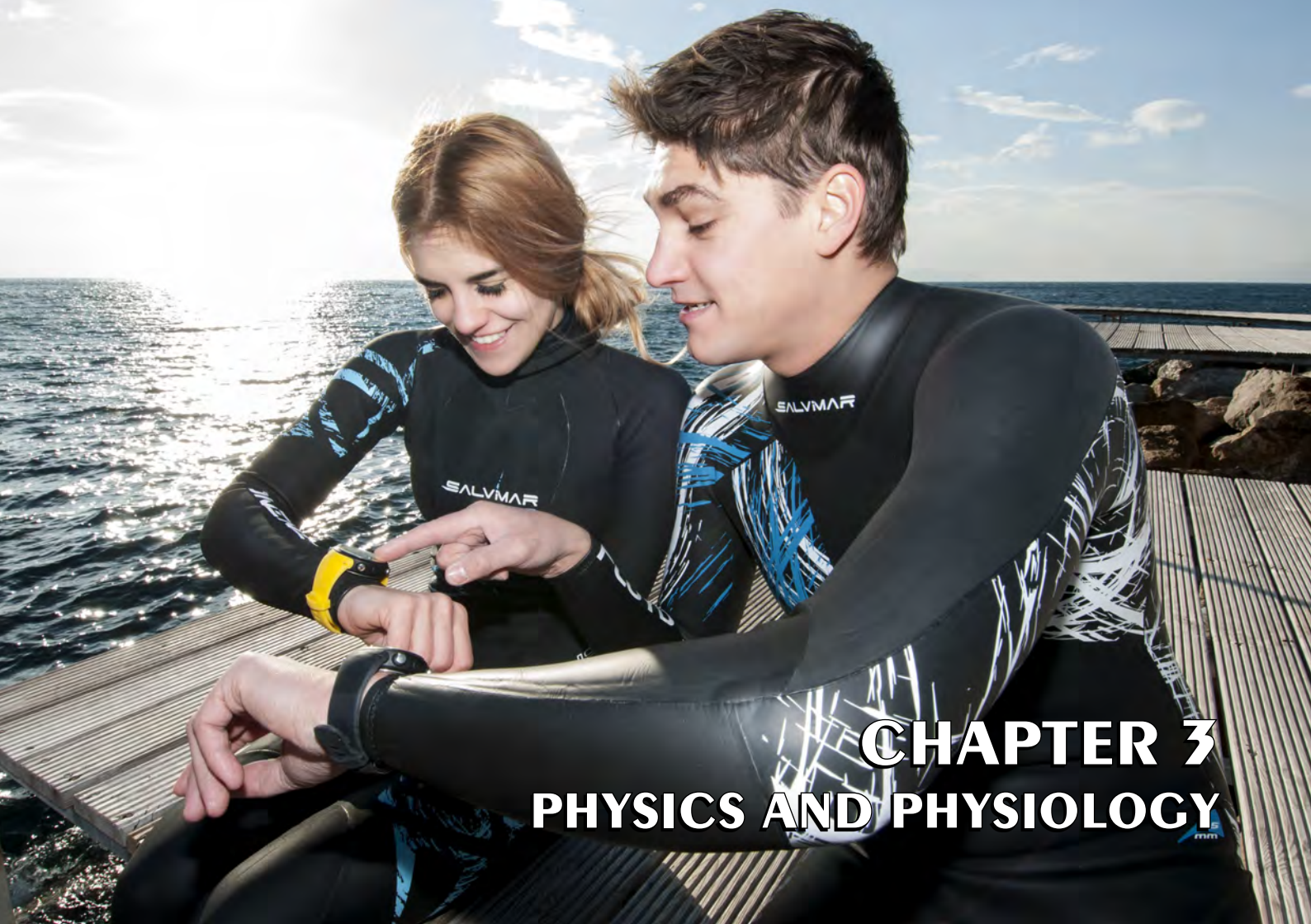
CHAPTER 2 STUDY GUIDE

1. Which type of breathing technique do you use every day?
 - ☐ Thoracic breathing.
 - ☐ Diaphragmatic breathing.
 - ☐ Both.
2. Which type of breathing technique should you use when preparing to hold your breath?
 - ☐ Thoracic breathing.
 - ☐ Diaphragmatic breathing.
 - ☐ Both.
3. The diaphragm separates:
 - ☐ The lungs from each other.
 - ☐ The lungs from the heart.
 - ☐ The thoracic cavity from the abdominal cavity.
4. What happens when the diaphragm contracts?
 - ☐ The internal organs are pushed upwards.
 - ☐ The lung capacity increases.
 - ☐ The chest flattens.
5. The lower third of the lungs supports half of the bloody supply to the lungs.
 - ☐ True.
 - ☐ False.
6. What do the pulmonary stretch receptors do?
 - ☐ Stimulate the breathing reflex.
 - ☐ Indicate how much air has been inhaled.
 - ☐ Help prolong how long you can hold your breath.



7. After holding your breath, preparatory breathing helps to re-establish the right levels of gas in the blood.
 - ☐ True.
 - ☐ False.
8. During the breathing sequence, how long should you inhale for?
 - ☐ 3-5 seconds.
 - ☐ The same length of time as the exhalation.
 - ☐ Both.
9. How many final breathing sequences should you do before freediving?
 - ☐ 2.
 - ☐ 4.
 - ☐ 6.
10. What are the effects of hyperventilation?
 - ☐ It increases the concentration of carbon dioxide in the body.
 - ☐ It reduces the concentration of carbon dioxide in the body.
 - ☐ It increases the concentration of oxygen in the body.





CHAPTER 3

PHYSICS AND PHYSIOLOGY





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CHAPTER 3

When you hold your breath and immerse yourself in water, your body goes through a very different experience to what you are normally accustomed to. Not only are you venturing into a very different environment to that of dry land, you are also doing it in a state that you are not used to: apnea, or holding your breath. Because of this, it is important that you understand what is happening to your body and what your physiological responses are when you go underwater while holding your breath. In the first chapter, we mentioned how the water's characteristics affect our body, lowering our body temperature, changing our buoyancy and impairs our vision. Now we will provide more detail about the laws of physics that govern

these changes and the physiological mechanisms that affect your body when you hold your breath.

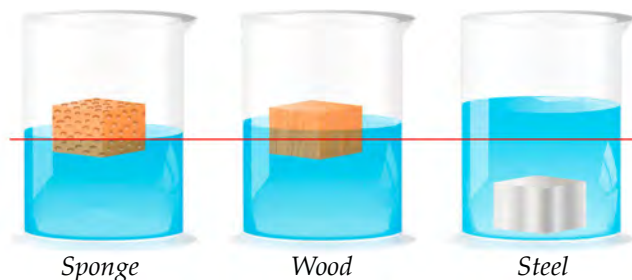
In this chapter, you will learn how water influences pressure, volume, density, sound and light, understanding how these changes affect your body and how to react to compensate for the changes safely.

BUOYANCY (ARCHIMEDES' PRINCIPLE)

Have you ever wondered how a ship can float on water despite being made of tons of metal? The answer was discovered by the Greek mathematician Archimedes. In fact, he discovered that each time an object is immersed in liquid, the liquid exerts a force



Archimedes' Principle



in the opposite direction, which varies according to the volume of the object. After many tests and experiments he formulated a principle, which was later named after him.

Archimedes' Principle states that *a body immersed in a liquid is subjected to an upward force equal to the weight of the liquid that it displaces.*

This means that:

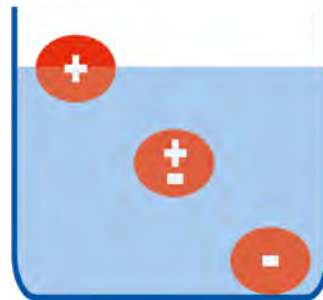
- If an object displaces a quantity of water that weighs more than the object, the object will float (*positive buoyancy*).
- If an object displaces a quantity of water that weighs less than the object, the object will sink (*negative buoyancy*).
- If an object displaces a quantity of water that weighs the same as the object, the object will neither float nor sink but will remain in the original position (*neutral buoyancy*).

So, coming back to the original question, the ship

Effects of the Archimedes' Principle

A body immersed in Water can have a buoyancy that is:

- (+) *Positive, when you float;*
- (-) *Negative, when you sink;*
- (+/-) *Neutral, when the body remains in the same position.*



floats because its hull displaces such a large quantity of water that it weighs more than the boat itself.

When you are in the water, your body is subjected to the same effects described by the Archimedes' Principle and you can have different "buoyancies" based on your physical characteristics and the equipment you are wearing. Everyone has a specific body density based on the density of our muscles and bones. Normally, heavier people need to add more weight to their belt to help them sink, people with more adipose tissue, or fat, need more weight than someone who weighs the same but who has a greater muscle mass.

Buoyancy is an essential part of freediving, representing an important safety mechanism as well as a means to manage your dive. Unlike scuba diving with a tank, where our buoyancy needs to be neutral on the surface, when we freedive we need to obtain a neutral buoyancy at a precise depth of 10 m/33 ft.



There are various reasons why it is important to be neutrally buoyant at depth and not at the surface:

- To reduce the risk of barotrauma to the ears, caused by a rapid, uncontrolled descent due to excessive weight;
- To save energy during the final few meters of the ascent, allow the positive buoyancy to help us reach the surface;
- To increase the speed of ascent for the final few meters and to reduce the risk of Shallow Water Blackout (SWB; this will be explained in more detail in the following chapters), from the moment that the buoyancy becomes slightly positive when surfacing;
- To enable a diver's buddy to bring them to the surface in the unlikely event that Shallow Water Blackout (SWB) occurs.

Important Notice. Be careful not to use less weight than necessary. If your buoyancy is too positive in relation to your correct weight, you will use a lot of energy to reach the desired depth and will descend very slowly, which will reduce the time you can spend practicing.

Be careful not to use more weight than necessary. If your buoyancy is too negative in relation to your correct weight, you will descend too quickly and you could suffer barotrauma to the ears. Moreover, surfacing will be tiring as you will be carrying excess weight behind you, using more energy and therefore more

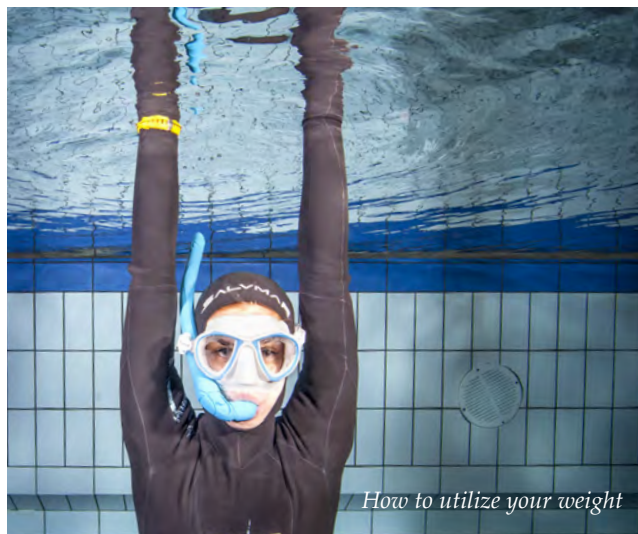
oxygen.

Remember, when freediving it is essential to always return to the surface in a calm and relaxed manner.

Descending underwater

Each freedive is preceded by a surface dive, so you need to acquire an excellent grasp of this technique. A correct surface dive enables you to use less oxygen and energy, and puts you in the most hydrodynamic position possible when underwater.

Remember, the surface dive is not a question of strength but rather technique, using your body weight

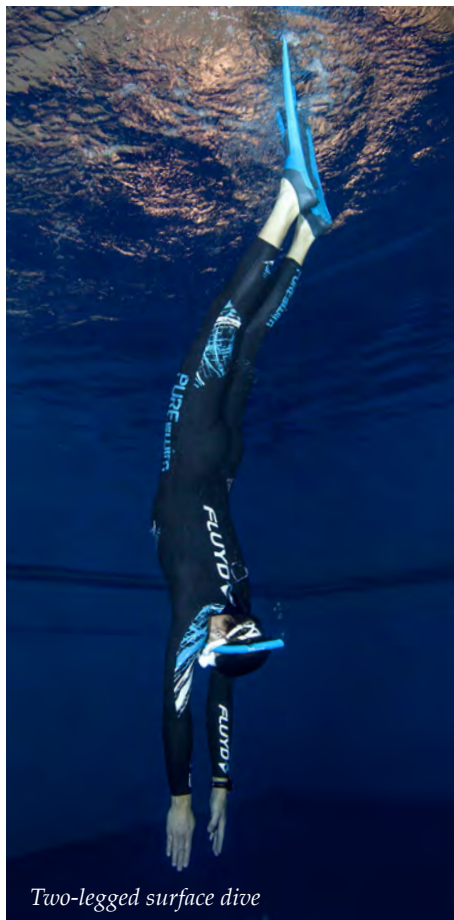


How to utilize your weight

to propel your body underwater.

How to utilize your weight. To gain a proper understanding of how the surface dive is a question of weight rather than strength, adopt the weight-controlled position (knees tucked into your chest, arms around your legs) and raise your arms above your head. You will see how you begin to sink, as the weight of your arms forces the body below the surface of the water. The same thing happens when you perform a surface dive, and you must simply utilize the weight of your legs to sink effortlessly.

Two-legged surface dive. Lie on your stomach with your snorkel on and your arms relaxed pointing towards the bottom of the pool. Put your legs together, bring the heels towards your backside and bend the knees (keeping them together), then at the same time bring your chin against your chest and lower your shoulders. When your heels are near your backside, extend your legs but push them out of the water, trying to keep the arms and legs



Two-legged surface dive

in a line that is perpendicular to the water surface. As the weight of your legs pushes you downwards, start kicking as soon as you feel your fins enter the water.

Surface dive with the arms. Lie on your stomach with your snorkel on and your arms stretched out on the surface of the water in front of you. Push your arms towards your feet, passing them alongside your body with your elbows bent, then immediately after bring them above your head, keeping them straight and in front of your body, bring your chin to your chest and lower your shoulders. As your body bends downwards and your legs come out of the water, keep your legs vertical above your body. Repeat the first movement with your arms, pushing them towards your feet and keeping them alongside your body; this final movement will take you completely under the water.

Free Immersion Descent: You can also descend in water with just the strength of your arms, without using your fins. Hold on to the guide rope with one hand and pull yourself downwards, keeping your head facing down and looking at the rope. When the arm holding the rope is fully extended, extend the other arm down and grasp the rope, then repeat this movement until reaching the desired depth.

PRESSURE

Although the concept of air as a “substance” was considered by the ancient Greeks, it was not until Galileo’s time that physicist Evangelista Torricelli demonstrated that the Earth’s atmosphere at sea level exerts enough pressure to push 760 mm (29.92 in) of mercury (Hg) through an empty glass tube.

This phenomenon is due to the fact that we live at the bottom of an ocean of air that is influenced by the force of gravity and is therefore “compressed” against the Earth’s surface. This ocean of air is called the atmosphere and extends upwards for tens of kilometers (or miles). As air has mass, it exerts its own pressure which is distributed so evenly across our bodies that we don’t notice it. The pressure that air exerts on our body is called atmospheric pressure and corresponds to the weight of a column of air of one square centimeter measured from sea level to the top of the Earth’s atmosphere. This has a mass of around 1 kg (2.2 lb), which is usually indicated as 1 atmosphere (atm) or 14.7 lbs per square inch, commonly indicated as 14.7 psi (pounds per square inch).

Later, the French philosopher and scientist Blaise Pascal



Free immersion dive





Pressure at sea level
is 1 atm.

1 atm	
1.01	bar
101.325	Pa
1.03	Kg/cm ²
760	mmHg
29.92	inHg
14.7	psi

demonstrated that the weight of the atmosphere was equal to the pressure exerted by 10 meters / 33 feet of seawater. This means that when you freedive, the pressure increases by 1 atm (14.7 psi) for every 10 meters/33 feet of depth.

Therefore, at a depth of 10 meters/33 feet, the pressure equals the sum of 1 atm (14.7 psi) of atmospheric pressure plus 1 atm (14.7 psi) of water pressure (hydrostatic pressure), so at 10 meters (33 ft) you are subjected to an ambient or 'absolute' pressure of 2 atm (or 29.4 psi).

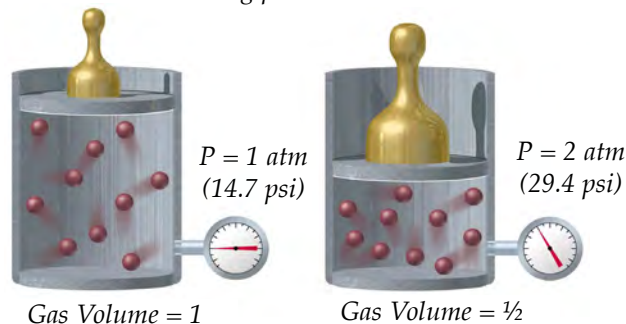
You have probably already experienced the effects of increasing pressure when swimming underwater.

Maybe you remember diving in a swimming pool to collect something from the bottom, when you always needed to make a final push just as the pressure began to make your ears hurt. This discomfort is caused by the pressure increasing as you descend.

Boyle's Law

To become a freediver, you need to understand the effects of pressure on the human body and how to deal with it. Continuing Torricelli's work, the Anglo-Irish scientist Robert Boyle discovered that as pressure increases or decreases, the behavior of a gas is extremely predictable. His findings, known as Boyle's Law, state that if pressure is increased in a container (such as a balloon) at a constant temperature, the volume of the gas decreases. The exact opposite is also true when the pressure is reduced. Based on what we have learned so far, we can easily calculate the ambient (absolute) pressure to which the body is subjected at the various depths during a dive. At 10 meters/33 feet, the pressure is double that on the surface, so 2 atm (29.4 psi); at 20 meters/66 feet it is

Boyle's Law
Increasing pressure reduces volume

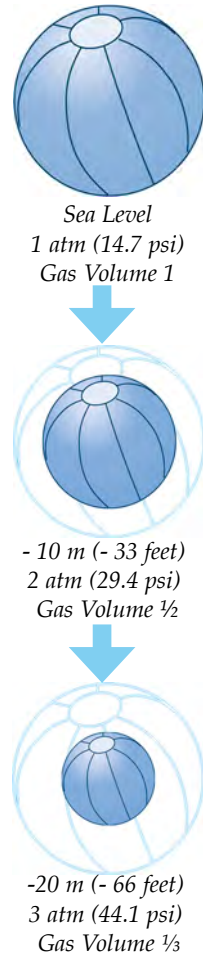


triple, or 3 atm (44.1 psi); at 30 meters/99 feet it is four times greater, or 4 atm (58.8 psi). Similarly, the volume of a gas in a flexible container will decrease in proportion to the depth (pressure). For example, at 10 meters/33 feet (2 atm or 29.4 psi) the container will have half the volume it had on the surface; at 20 meters/66 feet (3 atm or 44.1 psi) it will have a third; at 30 meters/99 feet (4 atm or 58.8 psi) a quarter, and so on.

What effect does this pressure have on your body? The human body is composed of around 70% liquids and 30% solids and gases. Our liquids and solids are not affected, however pressure can significantly impact on the air-filled spaces in our body causing so-called "direct effects".

The air cavities in our body are the lungs, respiratory tract, cranial sinuses, gastrointestinal tract (stomach and intestine) and the ears. These structures do not have rigid walls and can expand and contract, and consequently we need to equalize any pressure exerted on them.

Equalizing pressure means keeping the pressure of a gas contained in a flexible container equal to that of the external pressure. The pressure may be equalized in one of the following two ways:



- By changing the volume. If external pressure increases on a flexible internal cavity, causing the volume to decrease, the pressure of the gas inside the cavity will increase in proportion and the internal and external pressures will be equal.
- By introducing gas into the internal cavity to equalize the pressure. If you introduce an adequate amount of gas into the internal cavity as the external pressure increases, the internal pressure will remain balanced with the external pressure and the volume of the cavity will not change.

These two equalization methods happen when we freedive: the abdominal organs and the lungs are equalized by a reduction in volume. Thanks to the *blood shift* phenomenon, the missing volume is compensated by increased blood flow to prevent the solid and therefore incompressible chest from collapsing.

In contrast, the ears and cranial sinuses must be equalized by introducing air.

Equalization techniques

The ear is a complex organ designed for two important functions: hearing and balance. It is divided into three sections: outer ear, middle ear and inner ear. The outer ear





is formed of the auricle and the outer ear canal. The tympanic membrane, more commonly known as the eardrum, separates the outer ear from the middle ear and transmits sound vibrations to the inner ear. The middle ear is a small cavity containing air, and is connected to the airways (pharynx) through the Eustachian tube. This tube is normally closed, so the middle ear is essentially a closed container that is exposed to external pressure by the flexible wall of the eardrum. If external pressure increases, the eardrum can flex inward to some extent to change the volume of the middle ear. However, the pressure we are subjected to when diving is such that we need to enable the Eustachian tube to open so that air can enter into the middle ear to equalize it.

There are two main methods of equalizing the ears: the “Valsalva maneuver” and the “Frenzel maneuver”. To perform both of these techniques, we need to pinch the nostrils closed and breathe gently through the nose. The difference between the two maneuvers depends on where the air used to equalize the ear comes from. In the Valsalva maneuver, the air comes from the lungs, as the contracting abdominal muscles force the air into the upper part of the airways and, because the epiglottis is open, the air reaches the mouth and enters into our nasal cavities before reaching the middle ear via the Eustachian tube. In the Frenzel maneuver, the air used to equalize the pressure is taken from the mouth and the upper part of

the pharynx. In fact, during the latter maneuver the epiglottis is closed and the air is forced into the Eustachian tube by moving the tongue in a similar way to when we swallow.

Both techniques are effective ways of equalizing pressure, but the Frenzel maneuver is more suitable for freediving. This is partly because the Valsalva maneuver uses larger muscle groups and so requires more energy. Furthermore, we equalize pressure when freediving with our heads facing down, meaning the air is being forced in the opposite direction to its natural flow. Consequently, if we use the Valsalva maneuver the air has to travel further than it does when performing the Frenzel maneuver as it originates from the lungs rather than the mouth and pharynx. Finally, as you will learn in the *Deep Freediver* and *Master Freediver* courses, the Valsalva maneuver cannot be used at all depths. In fact, beyond certain depths when the volume of the lungs is reduced by external pressure, it becomes impossible to force the air from the lungs to the upper part of the airways.

Your instructor will help you to understand which equalization method to use and will advise you on how to perfect and master pressure equalization when freediving.

In both cases, it is important to never perform the maneuver with too much force. It is essential to keep the difference between water pressure and middle ear pressure to an absolute minimum to be able to easily

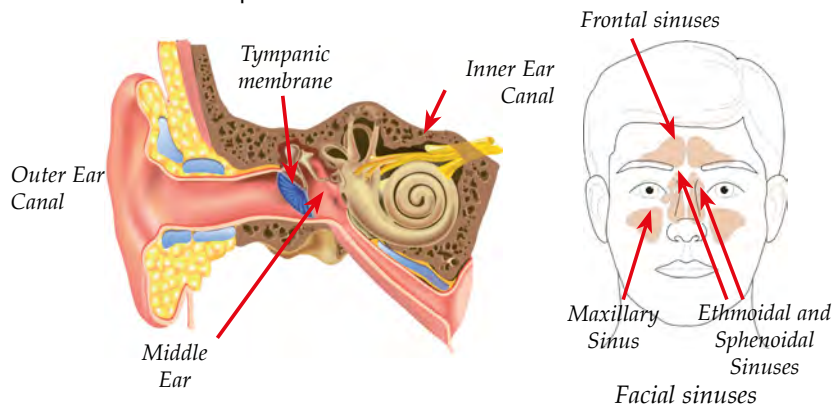


perform the equalization maneuvers. This means that the pressure should be equalized immediately, starting at the surface before you even begin to descend. If the air spaces inside the ears are properly equalized, you shouldn't experience any discomfort.

Continuing a descent without properly equalizing the ears can rupture the eardrum or cause hearing damage.

Remember, always equalize immediately, gently and slowly. Never force equalization!

The sinuses are cavities present in the skull. They are connected to the nose and throat by a dense network of passages. Normally, the airways inside the sinuses are open and are equalized when the ears are equalized. However, sometimes equalizing the sinuses can be difficult due to obstruction of one or more tubes due to swelling and congestion caused by a cold, allergies, infections or other disorders. This may cause pain on the forehead, cheekbones or upper teeth. If this occurs, it is best to postpone the dive until the problem has been resolved.



Equalization. Grasp the guide rope then maintain a vertical position with your head on top and pull yourself downwards by moving one hand below the other on the guide rope. Before moving each hand, perform the equalization technique.

As explained in chapter one, we also need to equalize air pressure inside the mask. Failure to equalize the mask properly may exert pressure on your face during your descent. When you return to the surface, your eyes may be red and bloodshot: this is referred to as a “mask squeeze”.



This is very easy to prevent: simply exhale a little air through your nose during your descent to equalize the pressure inside the mask with the ambient pressure.

The symptoms from a “mask squeeze” pass easily. However, if you start to feel the onset of a “mask squeeze”, it is best to postpone the diving session.

Surfacing

As we explored earlier, reducing pressure means that the volume of gas increases, and this happens when you are surfacing from a freedive.

As we surface, any excess air inside the middle ear should easily from the Eustachian tube without you needing to intervene. However, sometimes a diver may suffer from dizziness and the ears may “swell” when surfacing, causing pain to the cranial sinuses. In this case, an reversed squeeze is taking place: this means the mucus in the internal cavities is preventing the flow of air, or that the soft tissue of the Eustachian tube is swollen and blocking the air held inside the middle ear. This can occur after the use of nasal decongestants as the effects wear off during diving. This discomfort is rare when freediving as the time spent underwater is very brief and often not long enough for the effect of the drug to fade. It is more likely that the effects will diminish on the surface and this makes equalization difficult when descending. Either way, an inverted squeeze is a very serious condition for freedivers as, unlike scuba divers, they can't pause when



surfacing to release excess air gradually. In the event of an inverted squeeze, postpone the diving session, and always avoid using decongestants on your open water dives. *If you have a cold or are suffering an allergic reaction, avoid diving altogether!*

Another important factor to consider is lung over-expansion. This condition mainly affects scuba divers who dive with a tank. Scuba divers' lungs are full of air even when they are diving at depth and as they surface this air begins to expand, causing serious damage if they continue to hold their breath. *For this reason, never breathe from an aqualung when freediving, even if you are a qualified scuba diver.* This can cause serious damage to the lungs when you surface and may result in very severe and dangerous consequences.

Turn-up and ascending. When you reach your desired depth, it is important to change course before returning to the surface. This maneuver must be as relaxed as possible to avoid wasting energy and using too much oxygen. When you reach the marker that signals your desired depth, gently grasp the guide rope and let the momentum pull your body downwards. Your body will then rotate around the hand that is holding the rope. In this way, gravity and inertia bring you back to a vertical position with your head up, enabling you to conserve energy that can help when surfacing in a more relaxed manner. Before beginning to surface, check that your position is parallel



to the guide rope and that this is a safe distance away so as to be in easy reach but not present an obstacle.

GASEOUS EXCHANGE AND BREATHING REFLEX

Each breath starts with nerve impulses being sent from the brain to the respiration muscles. The contracting intercostal muscles raise the ribs, while the diaphragm lowers the abdominal cavity. These muscle movements enable our lungs to expand and fill with air.

The lungs are effectively spongy sacks (alveoli) connected to capillaries. On each breath, air is carried to the lungs through the airways (nose, mouth, pharynx, larynx, trachea and bronchus).

At sea level, air contains approximately 21% oxygen and 79% nitrogen, as well as small amounts of other gases which aren't relevant in this context. The oxygen and nitrogen in the air enter the lungs as we breathe and are absorbed into the blood through the thin walls of the alveoli in the lungs.

As an inert gas, nitrogen doesn't dissolve in the blood and isn't involved in the gaseous exchange. However, because of the way our heart works, oxygen is transported around our body by the arteries and is used to supply our cells. This process is called cellular respiration: the cells acquire the oxygen from the blood and use it as an energy source, then release

carbon dioxide, effectively the waste product of cellular respiration.

Near the surface of the body, the red blood cells (the cells that carry the two gases) release oxygen to the cells and collect carbon dioxide, returning it to the lungs through the veins. It is then passed into the alveoli and exhaled to make room for pure air and start a new breathing cycle.

Carbon dioxide plays a fundamental role in the respiratory process, as the breathing reflex is stimulated by the level of carbon dioxide in the blood. As soon as this level rises, the respiratory center in the brain sends an increasing number of signals via the central nervous system to the breathing muscles.

These signals can be felt distinctly: swallowing, a warm sensation in the chest and diaphragmatic contractions. If you feel any of these symptoms, you should postpone the diving session immediately and start breathing again.

This is what determines how long you can hold your breath. When you are underwater, your body begins to use oxygen, in particular to fuel the muscles that enable you to swim and maintain your vital and brain functions, and produces carbon dioxide that requires you to breathe again. The speed with which your body uses oxygen and its tolerance to the build-up of carbon dioxide are things that you will develop as you improve your freediving ability.

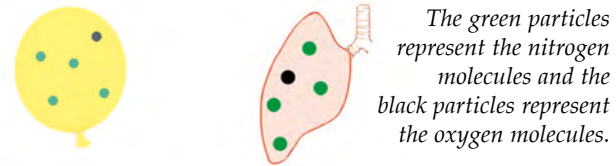


GAS MIXTURES AND PARTIAL PRESSURES

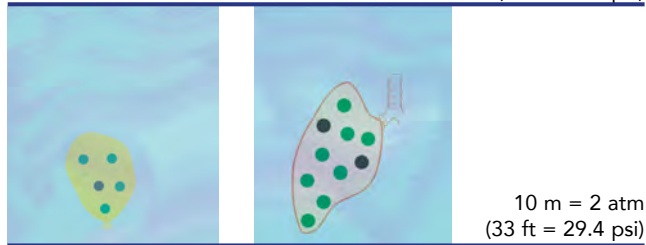
Up until now, we have discussed how a gas works without worrying about whether that gas is comprised of one or more elements. Now we are going to look at how a gas behaves when it is formed of a mixture of different gases. A good start is to ask ourselves how to evaluate each gas in the mixture.

The first person to examine this issue was the English scientist John Dalton. He proved that each gas in a mixture behaves as though the other gases do not exist.

For example, air is made up of 79% nitrogen and 21% oxygen, so 79% of air pressure is exerted by nitrogen and 21% by oxygen. This phenomenon is known as Dalton's Law. Dalton referred to these individual pressures within a mixture of gas as "partial pressures" and found that each partial pressure is proportional to the number of molecules of that gas present in the mixture. We will now look at how that concept applies to freediving. During our everyday lives we all breathe air, which is made up of 79% nitrogen and 21% oxygen, plus a tiny percentage of inert gases that for convenience's sake won't be considered here. We know that the pressure we are subjected to at sea level is 1 atmosphere (or bar). According to Dalton's Law, oxygen exerts 21% of total air pressure, while nitrogen exerts the remaining 79%. We can then calculate that of the total pressure of 1 atm (14.7 psi), the partial pressure due to oxygen is 0.21 atm / 3.1 psi



0 m = 1 atm (0 ft = 14.7 psi)



(so 21% of 1 atm / 14.7 psi) while the partial pressure exerted by nitrogen is 0.79 atm / 11.6 psi (so 79% of 1 atm / 14.7 psi).

We've also learned that if we dive to a depth of 10 meters (33 ft), the total pressure will be 2 atm / 29.4 psi. According to Dalton's Law, each component of the gas mixture continues to exert its partial pressure in proportion to its percentage. As we have discussed, the total pressure is 2 atm / 29.4 psi, so of this, oxygen will exert 21% (or 0.42 atm / 6.2 psi) and nitrogen will exert 79% (or 1.58 atm / 23.2).

We have also seen that as pressure increases, partial pressure also increases, and as the opposite is also true, this can cause serious difficulties when freediving.



Let's suppose that having dived to 10 meters / 33 feet, a freediver has used half of the oxygen in their lungs. At this depth, the partial pressure would still be enough to support the vital functions. In fact, if the freediver has used half of the oxygen in his lungs, the percentage of remaining oxygen will be 10.5%, which at 10 meters /33 feet depth will exert a partial pressure of 0.21 atm / 3.1 psi, in effect the same pressure as oxygen exerts when we breathe on land. Therefore, at this depth the gas in the lungs is enough to supply the diver's oxygen needs. However, as the diver returns to the surface, the partial pressure of the oxygen will drop dramatically and may fall below the minimum limit required to maintain the diver's vital brain functions. This may cause loss of consciousness which, unless the diver is immediately rescued could result in drowning. This is one of the reasons why freediving should never be practiced alone.

Hypoxia and problems linked to breath-hold diving

Hypoxia is the term used to describe oxygen deficiency in the body. Normally our bodies are adapted to live in a normoxic environment, which means an environment where oxygen exerts a partial pressure of 0.21 atm / 3.1 psi. As we have stated previously, when

Depth	Absolute Pressure	Partial Pressure O ₂	Partial Pressure N ₂
Sea level	1 atm (14.7 psi)	0.21 atm (3.1 psi)	0.79 atm (11.6 psi)
10 m (33 ft)	2 atm (29.4 psi)	0.42 atm (6.2 psi)	1.58 atm (23.2 psi)
20 m (66 ft)	3 atm (44.1 bar)	0.63 atm (9.3 psi)	2.37 atm (34.8 psi)
30 m (99 ft)	4 atm (58.8 psi)	0.84 atm (12.4 psi)	3.16 atm (46.4 psi)

we dive we use oxygen, and this reduces the amount of oxygen within our bodies to create a hypoxic environment. Our body is accustomed to working in normal conditions, with a partial pressure of oxygen that varies between 0.21 and 0.16 atm (3.1 psi and 2.4 psi). In fact, in a normal breath, the air we exhale contains around 16% oxygen. If we go below this limit, we may encounter the first signs of serious hypoxia which may result in other very dangerous conditions. Given that there is a very real possibility that these conditions may arise, it is important to understand how to recognize them, how to prevent them from occurring and how to help your buddy if they do happen.

Shallow Water Blackout (SWB) and Blackout (BO)

Shallow Water Blackout (SWB) is so-called because it typically occurs in the final few meters/feet before





surfacing, usually in the final third phase of the ascent. SWB is a loss of consciousness due to a drastic reduction in partial pressure of oxygen, as described above. Usually, freedivers will simply lose consciousness and stop kicking; the arms will fall to their sides, the head will flop forwards or backwards and the eyes will close or roll back. It is very common for SWB to be followed by an exhalation, so you might see a bubble escape from the mouth: this is a clear sign of SWB and you must respond using the techniques described below. Moreover, the diver may begin to sink, either because of loss of buoyancy if they are too heavily weighted or if they are still in deep water. Blackout may also occur at the surface if the diver resists the urge to breathe for too long and the oxygen levels in the blood fall below the levels required to support brain activity. *This is why it is extremely important to breathe immediately after the first diaphragmatic contraction.*

Blackout may also occur after taking a few breaths as oxygen needs a few seconds to reach the brain after being inhaled.



Loss of Motor Control (LMC)

Loss of Motor Control (LMC) consists of a series of muscular contractions or surface convulsions that occur at the end of a dive. They can happen after surfacing from a deep dive or at the surface/in shallow water following static or dynamic apnea. LMC can last for a short period or cause the diver to lose consciousness. The signs and symptoms of LMC include cyanosis, convulsions, tremors, irregular breathing, a vague stare and apathy. LMC is also caused by hypoxia when the oxygen levels in the body are not sufficiently high to maintain normal vital functions.

To prevent SWB, BO and LMC you must:

- Avoid hyperventilation;
- Never exceed your limits: don't dive too deep or hold your breath for longer than your level and experience allow you;
- Breathe correctly before and after diving (we have explored how to breathe correctly in each diving phase in the previous chapter);
- Rest between two consecutive dives, allowing your body to recover for 3-5 minutes before beginning the next dive;

Never dive alone, always dive with a buddy!

Rescue

As we have just learned, even if we implement all the preventative measures described above, some risky situations are always possible and as such it is

important to know how to deal with them. Often, oxygen deficiency in the blood creates problems that, if correctly recognized and managed, can be resolved in just a few seconds. For this reason, it is imperative to remain calm and carry out the following maneuvers logically and lucidly.

LMC and BO Management. If you notice that your buddy or a nearby diver is showing the first signs and symptoms of LMC or seems to have lost consciousness, the first thing to do is to call for help. Next roll him onto his back, face up. The first step is to establish positive buoyancy, so unbuckle and hand off or drop the weight belts. Remove his mask and, if necessary, his snorkel. Position yourself behind the unconscious diver, placing both hands on the sides of his head with your palms pressed against his ears, placing your middle or ring fingers below his lower jaw (be careful not to press the other fingers against the soft skin below the chin). Apply slight pressure to enable you to tilt his head gently backwards thus opening his airway. Blow strongly into his mouth and repeat: "Breathe! Breathe! Breathe!"

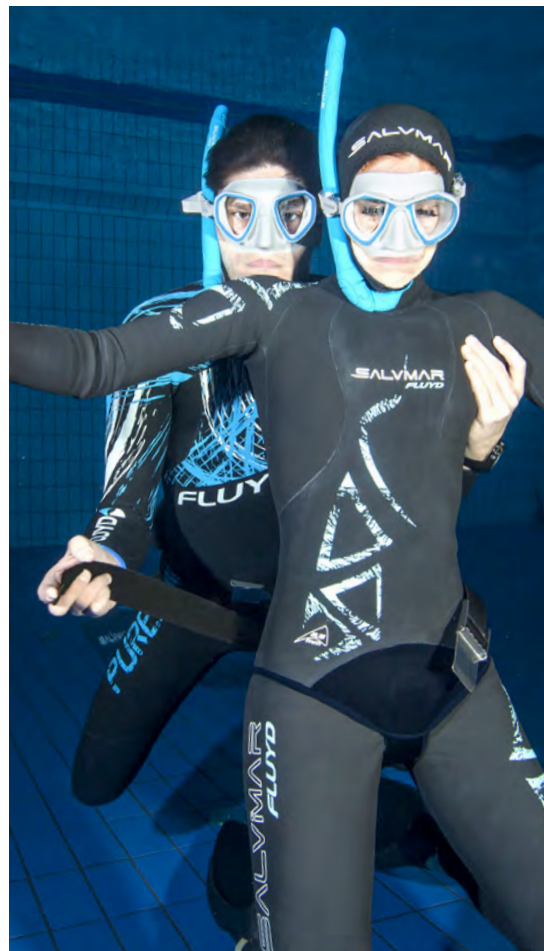
If he does not respond, you must begin to administer rescue breaths. Remove your mask and snorkel. Begin by giving two rescue breaths to attempt to interrupt the laryngospasm and kick-start the breathing reflex. If this doesn't work, remove your belt and begin to swim the unconscious diver to the shore, blowing into the opened airway every 5 seconds. Count





one thousand and one, one thousand and two, one thousand and three, one thousand and four, administer a rescue breath, then repeat until you reach the shore.

SWB Rescue. If your buddy experiences SWB during a dive, dive down to him, approaching from the right side so you can easily unbuckle his weight belt. Position yourself behind his shoulders and grasp him with your hands under his armpits. Bring him to the surface, keeping your arms extended above you so his body is above yours to make you more hydrodynamic and to avoid it hinders your fin kicking. Call for help as soon as you reach the surface. Remove his mask and, if necessary, his snorkel. Position yourself behind his head, placing both hands on the sides of the head with your palms against his ears. Apply



slight pressure to rotate the head backwards to open the airways. Blow energetically into his mouth and repeat: "Breathe! Breathe! Breathe!"

If he does not respond, you must begin to administer rescue breaths. Remove your belt, mask and snorkel. Begin by giving two rescue breaths to attempt to interrupt the laryngospasm and kick-start the breathing reflex. If this doesn't work, you need to swim the unconscious diver to the shore, blowing into the opened airway every 5 seconds. Count one thousand and one, one thousand and two, one thousand

and three, one thousand and four, administer a rescue breath, then repeat until you reach the shore.

In the event any of the scenarios described above manifests itself, stop the diving session immediately, even if the diver recovers completely. It is important to ensure that the affected diver leaves the water, undresses and dries off. Sit him in a comfortable position and monitor his vital signs.

FREEDIVING AND SCUBA DIVING

Freedives and scuba dives should never be combined. First of all, as described earlier it is very dangerous to breathe from a tank while freediving at depth. When surfacing, the inhaled air expands inside the lungs and can lead to lung overexpansion.

Furthermore, scuba diving uses compressed air stored in tanks that is then inhaled at depth, causing more nitrogen to be dissolved into the blood cells than we are accustomed to when we breathe on land. If you attempt to freedive after scuba diving, this greater quantity of nitrogen cannot be released correctly and can lead to decompression sickness. Before freediving, it is recommended to wait at least 12 hours after each no-decompress-



sion or no-stop dive, and at least 24 hours after a decompression or repetitive dive.

Although there is no clear evidence as to the dangers of scuba diving after freediving, it is strongly recommended never to go freediving and scuba diving on the same day.

TEMPERATURE

The human body operates and functions most efficiently within a narrow temperature range. When freediving, various circumstances can arise that, if incorrectly handled, can cause an excessive rise (hyperthermia) or fall (hypothermia) in body temperature. To dive safely and comfortably, you need to learn how to prevent these situations.

When the body is immersed in water, our body's initial response in order to prevent heat loss is to restrict the flow of blood to our limbs, namely by automatic vasoconstriction in our legs and arms. This helps to maintain a constant temperature in the center of the body, where our vital organs are located. However, if the body stays in water for a longer period, the restricted blood flow is not enough to maintain body heat and the body tries to create heat by contracting the muscles, causing us to shiver. Shivering is a sign that we are getting cold. Usually, the purpose of shivering is to produce heat, but when we are underwater we aren't able to produce enough to make up for



the amount of heat loss that has already occurred. As such, shivering should be considered a “limit”, after which the diving session should be brought to an end.

As we explored in the previous chapter, the best defense is to wear appropriate protective clothing, giving particular focus to the areas of greatest heat loss such as the head, neck, abdomen, groin, sides of the chest and armpits.

If the body temperature falls to 35°C (95°F), hypothermia sets in. If the body temperature falls to 32°C (90°F), the ability to think logically is diminished, and if it falls below 32°C (90°F) then there is a serious risk to life. If you experience shivering during a diving session, leave the water, put on warm clothing, warm up in the sun and drink a warm, non-alcoholic drink.

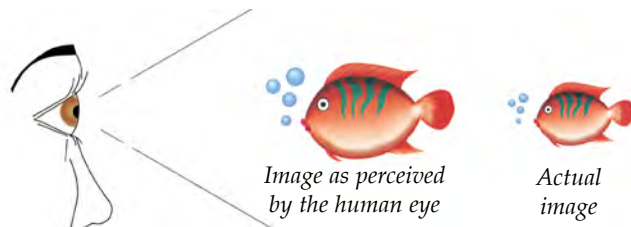
Although heat loss is an important factor in diving, so too is the need to avoid overheating (hyperthermia). Hyperthermia may be caused by wearing a dive suit for too long before or after a dive. The first symptom of hyperthermia is increased sweating, as your body attempts to lower its temperature by evaporating liquids through your skin. This process doesn't work if you are wearing a suit so don't put it on too soon. Other ways to avoid overheating are to avoid staying in direct sunlight for too long and to rinse off if the period between putting on the suit and getting into the water is prolonged.

VISION AND HEARING

All of our organs are perfectly adapted to life on land. Our eyes are particularly important when it comes to freediving as they let us appreciate the beauty of the underwater environment. As we mentioned in the previous chapter, to see clearly underwater you need an air pocket in front of your eyes, which is exactly what a mask provides. Despite this, our underwater vision is always slightly distorted compared to reality. Because of a physical phenomenon called refraction, rays of light entering the water bend, which makes objects appear approximately 25% closer and 33% larger than they actually are.

In reality, these objects are further away and smaller than they appear.

Light rays are not only refracted when they enter the water, they are also absorbed. This is another physical phenomenon that means there is less light as we descend. Because of this, warm colors like red, yellow and orange disappear in the first few meters; as depth increases, the rest of the spectrum also fades away





until everything appears blue and grey. If during your freediving career you want to make deep dives to explore and appreciate the beauty of the underwater environment and the marine life, it is worth investing in an underwater dive light. The first time you switch a dive light on underwater, you will be astounded at the array of colors that you see before you.

On land, we are able to determine where a sound comes from by unconsciously measuring the time it takes for the sound to be received by one ear and the other. Although this time difference is minimal, we are able to tell which direction the sound originated from even with our eyes closed.

Sound is produced when the vibrations of an object are transmitted to the ear via a conductor which carries sound waves. The denser the conductor, be it solid, liquid or gas, the faster and more accurately the sound is transmitted. Because water has a density that is 700/800 times greater than air, it conducts sound very effectively. Sound travels through water around four times faster than it does through air. This increased speed makes it very difficult for us to establish which direction a sound originates from, and this can be disadvantageous when we are trying to locate the origin of various noises such as an approaching boat.



SUMMARY

In this chapter you have learned about the changes your body undergoes when you freedive underwater, and what mechanisms your body implements to adapt to this new and different environment. You have also studied the risks connected to freediving, how to resolve them and, most importantly, how to prevent them. The sense of responsibility and skills that you have acquired up to this point will help you to become a responsible, safe and reliable freediver. You will be able to manage each stage of your diving sessions calmly and competently, comfortably knowing that you have done everything possible in terms of responsible risk management. This will enable you to relax and enjoy yourself as you practice this wonderful sport.



CHAPTER 3 STUDY GUIDE

1. At which depth should a freediver be neutrally buoyant?
 - ☐ At the surface.
 - ☐ At 10 meters (33 feet) depth.
 - ☐ At the maximum depth planned for the dive.
2. What weighs the same as the atmosphere?
 - ☐ 10 m (33 feet) of sea water.
 - ☐ 1 m (3.3 feet) of sea water.
 - ☐ 20 m (66 feet) of sea water.
3. At a constant temperature, if pressure is increased in a balloon, what happens to its volume?
 - ☐ It remains the same.
 - ☐ It increases.
 - ☐ It decreases.
4. At 10 meters (33 feet) depth in the sea, what is the volume of a flexible container full of air?
 - ☐ One third of its volume on the surface.
 - ☐ The same volume as on the surface.
 - ☐ Half of its volume on the surface.
5. How do you equalize your mask?
 - ☐ Exhaling a little air through your nose.
 - ☐ Exhaling a little air through your mouth.
 - ☐ Both.
6. What causes the breathing reflex?
 - ☐ The level of oxygen in the blood.
 - ☐ The level of carbon dioxide in the blood.
 - ☐ The level of nitrogen in the blood.



7. Diaphragmatic contractions:
- ☐ Occur following an increase of carbon dioxide in the blood.
 - ☐ Indicate that you should stop the dive.
 - ☐ Both.
8. What is the partial pressure of oxygen on the surface?
- ☐ 0.21 atm (3.1 psi).
 - ☐ 0.79 atm (11.6 psi).
 - ☐ 21%.
9. What is the partial pressure of oxygen at 10 meters (33 ft) depth?
- ☐ 0.42 atm (6.2 psi).
 - ☐ 79%.
 - ☐ 1.58 atm (23.2 psi).
10. When surfacing, the partial pressure of oxygen falls drastically, which:
- ☐ Enables you to extend the duration of the dive.
 - ☐ Can lead to Shallow Water Blackout.
 - ☐ Means you need to reduce the speed of the ascent.



A large, dome-shaped, textured coral structure, possibly a brain coral, is the central focus of the image. It has a light beige, pitted surface. The coral is situated on a diverse reef with various other coral species in shades of purple, yellow, and green. Numerous small fish are visible swimming in the clear blue water above the reef. Sunlight rays penetrate the water from the top left.

CHAPTER 4

THE UNDERWATER ENVIRONMENT



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CHAPTER 4



Nearly 71% of the Earth's surface is covered in water and each marine environment has its own unique characteristics. Becoming familiar with the different underwater habitats will help you to deal with any anxieties that may arise in unusual places and circumstances. The descriptions given in this chapter aim to help you gain a better understanding of the environments themselves as well as how to act in different situations. However, studying this manual alone is not enough to prepare you for a dive in all environments, and it is always best to seek specific information regarding any new area at a local Diving Center with qualified diving professionals.

TEMPERATURE AND VISIBILITY

Underwater temperature and visibility present the main factors that determine your comfort during a diving session. Diving in clear, warm waters is easier, you can wear a lighter exposure suit and the surface and depths are always in sight. Diving in cold and murky waters is much more challenging, you need to wear a thicker exposure suit that offers better insulation, and for much of the dive the guide rope forms your only visible point of reference.

Depending on your chosen diving area, water temperature can vary from around -2°C (28°F) (the





point at which salt water freezes) to above 29°C (84°F). Cold water dives are those that take place below 21°C (70°F) and require the use of an appropriate suit for the length of the dive, your diving ability and your physique. Therefore, water temperature is one of the main factors to consider when planning a diving session.

Usually the deeper the dive, the lower the water temperature. In cold waters there is often an abrupt temperature change between the surface layer and the deeper layer, known as a thermocline. The temperature between these two water layers can differ by up to 7°C (45°F); the two layers do not mix, they remain separate, and often the different densities of the two water masses results in a phenomenon that is clearly visible. If you are wearing thermal insulation having only considered the temperature of the surface water, the sudden change in temperature lower down may force you to dive only within that comfort zone. Thermocline is a phenomenon that usually happens in lakes, but it can also occur at sea, particularly in summer. As such, it is always advisable to check the deep water temperature at the local Diving Center. Visibility is another environmental factor that can have a major impact on your dive. Visibility is affected by the morphological characteristics of the diving environment, the movement of the water, the time of year and the weather conditions. For example, usually visibility is worse after rain and winter storms

and good during the calmer summer months. It is also influenced by tidal factors. Reduced visibility may cause frightening situations both when diving, as you can't see your desired depth, and when surfacing, when you can't tell how much further you have to go to reach the surface. In fact, it can be difficult to accurately calculate distances even in very clear water, and so it can be easy to go beyond the maximum depth planned for the dive. In these conditions it is essential to plan the dive correctly and, as always, for each diver to carefully supervise their buddy.

WAVES AND BREAKERS

All large water masses are constantly moving. Because of their low volume, freshwater environments are usually more stable than oceans. Waves are caused by wind blowing on the surface of the water. The height of the waves depends on the speed of the wind, its duration and the distance over which the wind blows (fetch). When the wind blows over a calm sea, small waves form on the surface. If the wind continues to blow, these waves become higher and the wind transfers more energy to the water. If there is an increase in the duration, speed and fetch, larger waves form and gradually become more regular. These waves will be of a similar size and will tend to move together at the same speed. In deep water environments, the energy of the wave only moves the



water on the surface, and the water below stays more or less in the same place. A boat floating on the waves will predominantly move vertically, with very little horizontal movement. A wave's energy will continue until it breaks against a beach or cliff. When the waves reach shallow waters, friction with the sea floor causes the lower part of the wave to slow down. In a nutshell, the top part of the wave travels faster than the bottom part. At this point, the crest of the wave falls and breaks, causing the backwash. The backwash is an oscillating horizontal movement that occurs near the coast when there is swell, causing a floating object to be pushed alternately towards the shore and out to sea.

TIDES AND CURRENTS

In many cases, water movement is caused by tides, resulting from the difference between the gravitational force of the Moon and, to a lesser extent, the Sun in different points on Earth. The variations in tidal water levels can vary from a few centimeters to a few meters. It is important for divers to understand tidal currents; these can be very strong and capable of carrying away even



a strong swimmer with powerful fins. In areas with strong tidal currents it is essential to seek local knowledge at a local Diving Center; these plan their diving sessions using tide tables during the slack tide, when there are no active currents. It is essential to consider currents when planning your diving sessions. Attempting to swim against a strong current can exhaust a diver in just a few minutes. When planning a dive where the entry and exit points are the same, it is important to always begin the dive against the current, as returning to the exit point will then be easier thanks to the natural movement of the water. To escape from a current, it is best to swim diagonally to it rather than attempt to confront it directly. Bearing environmental factors in mind when planning your dives will help you to dive safely and comfortably, and enjoy the magical moments of each dive.



UNDERWATER LIFE

Often, divers consider that the most important, if not only, purpose of diving is to attain and improve personal performance. In reality, the most fascinating aspect of this sport is undoubtedly the fact that it offers us the keys to an extraordinary world that occupies three quarters of our planet. These keys must be earned however, and learning correct freediving technique is only the first step. Discovering how the underwater world works and what this means requires some study but, most importantly, a healthy dose of curiosity and passion. As we have already mentioned several times in this manual, freediving is an inner journey and is primarily a personal experience, taking on different aspects for each diver and introducing them to the magical atmosphere of the ocean and its marine life. Unlike

scuba divers, freedivers are discreet and silent visitors to this world. This enables us to form a unique connection with the ocean and its inhabitants. Being able to approach often elusive creatures such as groupers, barracudas or shoals of sea bream, or stopping to glimpse an octopus or moray eel in its lair, may become common occurrences in your freediving career, and ones which we hope will encourage you to continue your training to explore the incredible variety of marine life forms in even greater detail. The following information is not intended as a thesis on marine biology, as this manual has neither the space nor the intention to do so. However, having taught you how to reach the silent depths of the ocean, it would be remiss of us not to offer some indication as to what you might encounter in these environments and how to learn to recognize and distinguish the major groups of marine life.



ECOLOGY

When we talk about marine organisms, it is important to understand a little bit about the environments in which they live. Having a basic understanding of the ecological needs of the different species and groups can help you to recognize them more quickly and find them more easily. For example, it would be pointless to look for algae inside caves as plants can't grow without light, and equally illogical to look for coral in sandy areas, by well-lit surface rocks or on wave-beaten terrain. Essentially, some of the basic conditions that regulate the distribution of marine organisms are light, the type of ocean floor (substrate) and hydrodynamics (waves and currents). There are many other factors in addition to these (temperature, oxygen, depth, presence of other organisms) but we can ignore these as more often than not



they are intrinsically linked to the main factors (you will quickly learn that beyond a certain depth there are abrupt variations in temperature). One of the first things new freedivers discover is how colors disappear the deeper they descend. This strange phenomenon depends on the filtering effect that the water has on the rays of the solar spectrum which, depending on their energy and therefore color, are able to penetrate to different levels. As such, red rays disappear in the first few meters, followed by orange and yellow, while blue and green (the colors of the sea) are able to reach depths of hundreds of meters. How light behaves under water has an important impact on marine life, as the plant life establishes at different depths depending on whether it uses red rays (such as green algae and seagrass) or green/blue rays (red algae) to survive, leading to stratification. Bearing these factors in mind, it is worth remembering that organisms (and animals) are divided into two main categories: those that need light, and those that don't. These preferences are often fundamental in determining the types of species you are likely to encounter; these can differ significantly even on the same rock, as parts of the face are exposed to the sun while others are in the shade. The type of substrate is another key factor that affects the distribution and abundance of marine organisms. Again, you will quickly notice on your first dives how rocky floors are much more interesting than sandy or muddy floors. This is because rock forms

the ideal substrate for biofouling organisms such as sponges, algae, gorgonians and bryozoans which, as they grow, cause more cracks and features in the rock and thus create new habitats for other life forms. This is particularly prevalent in the Mediterranean environment, referred to as a coralliferous ecosystem by marine biologists, where biofouling organisms such as gorgonians, corals, sponges and red algae are particularly common, and in tropical coral reefs where life is so vivacious that it never fails to astound first-time divers. Mobile floors are less varied because the sand, mud or pebbles are mixed up by the swell, thus preventing many organisms from attaching and causing them to live deep in the seabed. Another unique environment that bridges the two described above are seagrass meadows, whose characteristics can provide a habitat for hard and soft biofouling organisms. As mentioned above, the effect of the waves or currents on mobile floors is very visible and this leads to the formation of the typical underwater landscapes, similar to sand dunes, that can be seen as you swim above a sandy base. Although less visible, the effect of moving currents on marine organisms is no less important; gorgonians and other sessile organisms are molded by the currents, and the same happens to all filter feeder organisms that live attached to the substrate. This leads to two distinct ecological categories: those that prefer moving water, and those that thrive best in calm, sheltered waters.





MARINE ORGANISMS

Every field has its jargon and marine life is no different, and new divers may be put off by the Latin names used so casually by naturalists to classify and identify the ocean and its inhabitants. In reality, this is not meant to confuse the uninitiated, but rather the result of the necessity to have a name that is universally understood, from Lapland to New Zealand, and Latin is well-suited to this without risking offending anyone. This system groups living organisms according to a hierarchy of categories or 'taxa', which become increasingly broad and are structured like Chinese boxes, so that each category contains the one before. In ascending order, the first category is species. Very similar species are grouped into one genus. To form the modern classification, each species is assigned a scientific name formed of two Latin words (binomial nomenclature). The first word is capitalized and gives the name of the genus shared by all similar species, and the second word identifies that particular species. Similar genera (the plural of genus) are grouped in families, indicated by the -idae suffix added to the name of the most representative genus (e.g. members of the Serranidae family take the name Serranus, which include painted combers, while Labridae such as wrasses, take the name Labrus); similar families are grouped first in orders (e.g. Perciformes, Squaliformes) then in



classes (e.g. Mammals, Fish). Classes are grouped in phyla (singular: phylum) (e.g. Cnidaria, Porifera, Mollusca and Chordata for animals, Rhodophyta and Magnoliophyta for plants) and similar phyla form a kingdom.

Plants

Algae are the most common marine plant organism. In fact, the name algae isn't an official classification but indicates a group of plants with different living characteristics and biological structure. Like other plants, all algae contain chlorophyll, but they don't have roots, stems or leaves even if their structure sometimes resembles them. Their body, known "technically" as the thalus, can vary from microscopic dimensions to dozens of meters in length (such as Kelp), and takes a different shape depending on the species: ribbon-shaped, erect, plate-like, reticulate or encrusted like a carpet across the sea floor.

In the marine environment, marine phanerogams represent the plants in the upper strata, and share the distinctive characteristics of this group: roots, stems, leaves and even flowers and fruits. Although there are significantly less phanerogams than algae (there are only 4-5 known species in the Mediterranean), these plants are extremely important for the ocean economy and ecosystem, giving rise to vast meadows (the seagrass meadows are particularly well-known and are discussed in more detail below) that offer a habitat

where many animal species can live and reproduce, creating a true oasis of life.

Animals

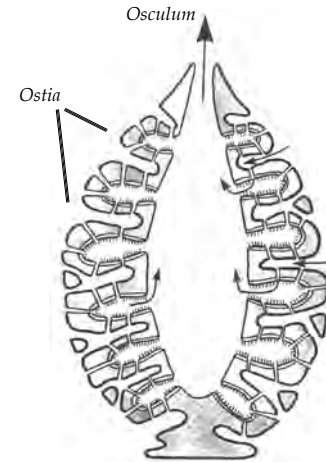
There are currently more than 170,000 known marine animal organisms, many of which live deep in the depths of the ocean. However, according to researchers, it is likely that there are another 2,000,000 species of animal in the marine environment that we haven't yet discovered. Obviously, this manual isn't intended to give a comprehensive list of these species. However, as a **SNSI Freediver**, it is important that you recognize the main groups of marine organisms that you will encounter during your dives.

Sponges (Poriferans) are a group of sessile organisms (i.e. that live attached to the ocean floor) that are predominantly found in marine waters and which usually have primitive characteristics. Sponges are typically characterized by flagella (lash-like structures) that drive the water containing oxygen and nutrients through tiny holes (ostia) within the organism's body. After use, water is expelled through larger, visible pores called oscula. The body varies in structure, from encrusted sponges to round or column-like shapes, and is made up of hard parts (calcium carbonate or silica) in the form of needles or fibers fused together by a collagen-like substance called Spongin.

A sponge's metabolism is designed to filter tiny particles of food from the surrounding water, enabling

it to settle in most habitats, from polar regions to underwater caves that often support very few nutritional substances.

Cnidarians, meaning nettles in Greek, take their name from cnidocytes, the unique stinging cells that characterize this phylum. This group includes corals, jellyfish and actinia (anemones). They are characterized by two body shapes across their lifecycle, the polyp form and the jellyfish phase. The polyp is a small sac fixed to a substrate, with a mouth facing upwards surrounded by a variable number of tentacles. The jellyfish has the same form but is mobile and the other way up, with the mouth pointing down. Cnidarians can move or contract, changing shape and appearance. This is very visible in beadlet anemones or in *Alicia mirabilis* which have drastically different shapes at night and day. Another characteristic of many cnidarians is the formation of colonies that, like in the case of coral and madrepores, reach such extraordinary dimensions that they create a specific habitat: coral reefs.





Species belonging to the *Mollusk* phylum look very different from one another but share a similar basic structure. Some of the best known mollusks are bivalves (oysters, mussels, clams), cephalopods (octopus, squid) and gastropods (nudibranchs, murex, cowries). They are characterized by a soft body with a distinguishable head (developed to a varying degree), a foot (the shape of which differs from one class to another), and a mantle, a fold of tissue covering all the internal organs and part of the foot. The mantle contains a calcareous shell formed of a single structure in the case of gastropods or two parts (or valves) in the



case of bivalves, and is not present in cephalopods. These have a very well-developed nervous system that enables them to move or change color rapidly.

Crustaceans belong to the Arthropod phylum; this is the largest group and also includes insects and spiders. Crustaceans are characterized by an external skeleton and numerous mobile appendages, including two front antennae. Crabs, lobsters (also called reptants, meaning they walk on the substrate) and prawns (called natants, meaning they can swim) also belong to this sub-phylum. These have a segmented form with a head and body which, in the most evolved



forms, is divided into the cephalothorax (including the limbs) and the abdomen. Unlike mollusks, whose shells grow over time, crustaceans periodically free themselves from their exoskeletons in order to grow, forming a new skeleton around their larger form.

Echinoderms are organisms found exclusively in marine environments and include sea urchins, starfish and sea cucumbers. They are covered with calcium carbonate plates (or in the case of sea urchins, spines) that protect the soft body from predators. These organisms are characterized by a radial symmetry with five symmetrical lines; this is visible in the adult form such as the five arms of a starfish. Another characteristic of echinoderms is the presence of a special series of

conductors (aquifer system) connected to water-filled muscle groups equipped with suckers. By varying the pressure of the liquid inside the muscles, the organism can attach and detach itself to or from the base, enabling it to move or catch prey.

Fish, which belong to the Vertebrate phylum (meaning animals with a spine), are marine animals characterized by a generally tapered and hydrodynamic body covered in scales, with paired (pectoral and ventral) or singular (dorsal, anal and caudal) fin-shaped limbs. They are subdivided into Chondrichthyes, characterized by a cartilaginous skeleton such as sharks and rays, and Osteichthyes, also known as “bony fish” because of their bone skeleton, which includes most





species of fish.

Marine *Reptiles* are represented by turtles and sea snakes. Turtles have a bony shell divided into a carapace or shield (the top part) and a plastron (the bottom part), and limbs (particularly the front ones) which are well suited to swimming. Turtles have separate sexes, although they are difficult to distinguish, and are oviparous (egg-layers). Unlike the males, the females return periodically to dry land where they lay their eggs on quiet and isolated beaches. Unlike turtles, at least three species of which are also present in the Mediterranean (such as the

Loggerhead sea turtle which reproduces on the island of Lampedusa), sea snakes are only ever encountered by scuba divers who explore the coastal regions of the Indo-Pacific. They are very similar to land snakes, the key difference being a flattened tail that enables them to swim more efficiently. Some species return to land to lay their eggs, while others spend their entire existence in the ocean. Other marine reptiles include the marine iguana found in the Galapagos Islands, and the marine crocodile commonly found from India to the Solomon Islands.

In terms of marine organisms, marine *Mammals*

are most akin to humans. When you take the SNSI *Advanced Freediver* course, you will discover that when we immerse ourselves in water, our physiological responses are very similar to those of marine mammals. Marine mammals are divided into three orders: Cetaceans (dolphins, whales and orcas), Pinnipeds (seals and sea lions) and Sirenians (manatees and dugongs).



MARINE ENVIRONMENTS

Seagrass meadows

Seagrass meadows are the most important marine environment in the Mediterranean. They are characterized by vast expanses of *Posidonia Oceanica*, or seagrass, which can grow from just a few centimeters/feet below the surface to 30 meters (100 feet) deep; in some cases, if the water is very clear and the light is able to penetrate further, they can even grow 40-50 meters (130-160 feet) below sea level. Seagrass is formed of roots, which anchor the plant to the seabed, a rhizome, which is a modified stem, and ribbon-shaped leaves which can reach 1.5 meters (5 feet) in length. Rhizomes can grow horizontally or vertically and are part of the so-called "mat", an intricate weave of rhizomes, roots and trapped sediment that forms the base of the meadow and helps to stabilize it. These characteristics enable the seagrass meadows to support very varied communities of animal and plant life. There





are *epiphyte* communities which colonize the surfaces of the leaves and rhizomes, formed mainly of bacteria and algae, and animal communities both sessile, which live attached to the substrate of plants and rhizomes, and vagile, which are able to move within the meadow.

Seagrass is the most extensive and complex ecosystem in the Mediterranean and plays a fundamental role in the survival of the Mediterranean as a whole for several reasons. Much like forests on land, it acts as a lung, with each square meter of meadow producing up to 20 liters (5 US gal) of oxygen each day. Many organisms use it as a reproductive area and it offers shelter for countless juvenile marine creatures. Finally, it guarantees the stability of the coastal seabed, counteracting the transportation of sediments by coastal currents and protecting the coast from erosion by softening the force of the current and swell.

Coral reefs

Even though they only occupy 0.2% of the entire marine environment, coral reefs are the most biodiverse marine ecosystem in the world and host around a third of all known marine species, gaining them the nickname of the tropical rainforests of the sea.

Coral reefs are formed of madrepores in an intricate three-dimensional structure which provides shelter to hundreds if not thousands of other animal and plant species. Coral reefs are predominantly found in the tropics and grow down to a depth of 30 meters (100

feet). However, this is purely indicative as you may encounter madrepores well beyond the tropics and at greater depths. However, most reefs are found within the limits suggested here for one main reason: madrepores thrive best in warm waters. In fact, these organisms struggle to grow in areas where the average temperature in the winter months is lower than 18-20°C (65-68°F).

Coral reefs are formed of coral polyps, and these create the living structure that represents the bulk of all reefs, formed for a soft part and a hard part. The soft part is the polyp itself. The polyp is housed in a hard, cup-shaped protective skeleton (corallite) formed of calcium carbonate and produced by the polyp itself. Each cup connects to the others to form colonies of varying shapes depending on the species of Madre pore. These colonies (branch-like, solid, rounded, flat, tendril-like or column-like, depending on the species and the environment) are able to reach colossal dimensions, such as bubble coral which can cover several square meters, or *Acropora hyacinthus* which can easily hide a diver. Corals that are able to form reefs are known as *Hermatypic* or “reef-building” corals and are usually associated with microalgae (*zooxanthellae*). Madre pores need this microalgae to survive, and the absence of it, as evidenced by the phenomenon of coral bleaching caused by the loss of the symbiotic algae, results in the death of the polyps. The polyp cups begin to form as soon as the

first polyp of a colony settles on a suitable, generally rocky substrate, and continue to be produced for the entire lifecycle of the colony, even if only the outer polyps are alive while those beneath, which by now have become solid rock, serve only as support.

HUMAN IMPACT

Humans have always used the marine environment as a resource, whether for food, recreation or economic gain. Considering that half of the global population lives within 100 km (60 miles) of the coast, it is not surprising that our actions have an effect on the marine environment. As the population continues to grow rapidly, this impact is increasing, resulting in overfishing, pollution and the introduction of non-native species.

Fishing

Humans, and coastal civilizations in particular, have used the sea as a food source since prehistoric times. However, because of modern technological developments (more efficient fishing equipment, more powerful boats, new tracking techniques), many fish stocks have fallen dramatically. In many areas, coastal fish reserves are believed to have been fished to capacity or overfished (meaning the number of caught fish is greater than the number of new organisms able to reproduce, which over time causes



the reduction and eventual disappearance of the stock). As well directly impacting stocks, unsustainable fishing practices can have other negative impacts on the marine environment. For example, other fishing techniques such as dredging and trawling can cause extensive damage to marine habitats and other organisms that live on the sea floor. These techniques often capture non-commercial fish (by-catch) which then are discarded and not used for food purposes.



Pollution

For a long time, the sea was used as an intentional garbage dump for various types of waste, including waste water, industrial waste and chemical products. Thankfully, currently policies have changed this behavior, introducing the idea that the ocean is not able to absorb our waste indefinitely and implementing measures to mitigate these serious situations. However, marine pollution continues to be a serious problem and poses a threat to all marine life. Some kinds of pollution can be accidental, such as oil spillages from tankers or wells, while others may be indirect, when pollution on land (from towns, agriculture, farming, etc.) reaches the sea through rainwater, groundwater faults or rivers; still other types of pollution are not instantly recognizable, such as bioaccumulation, when toxic chemical substances increase in each trophic level of the food chain as a result of predation. Many researchers believe that the problem of pollution may pose a serious threat to many "at risk" species that may be very difficult to mitigate.

Eutrophication

Eutrophication is the result of a particular kind of marine pollution. It is caused by the release of excessive nutrients in coastal areas transported by streams and rivers. These nutrients originate from the fertilizers used in farming and agricultural practices. A high concentration of nutrients in the sea can induce

excessive growth of Phytoplankton (tiny algae), resulting in blooms. This high number of developing plants rapidly exhausts the available nutrients and results in the death of the organisms themselves. During the decomposition process, bacteria quickly use up the remaining oxygen and this leads to hypoxia, which may endanger the lives of many other organisms.

Invasive species

Invasive species are species that were not originally present in a certain area, and whose introduction or spread has been caused by human activity. For example, many marine species have been introduced to environments thousands of miles away from their natural habitats. Often, the eggs, larvae and juvenile organisms are transported accidentally from one part of the world to the other in the ballast water of merchant ships, and then develop and adapt to live

in their new environment. Other invasive species were introduced for farming purposes and have escaped into the aquatic system, while others were released on purpose. Another example is the Lessepsian migration, characterized by the introduction of species from the Red Sea into the Mediterranean via the Suez Canal. Not all species that reach the new habitat are able to



survive and spread, but once they have established it can be difficult, if not impossible, to remove them. Invasive species are often introduced into a new habitat where they have no natural predators and are able to out-compete the local species, causing great imbalances in biodiversity.

Ocean acidification

There are various scientific studies that prove that human activity is causing a dramatic rise in the quantity of carbon dioxide in our atmosphere. This also impacts the marine environment, which currently absorbs around a third of all carbon dioxide emissions. The chemical reactions that originate from the CO₂ absorption reduce the pH and cause the water to become more acidic. Recent studies demonstrate that higher water acidity can cause serious harm to calcareous organisms (such as algae, coral or echinoderms), and many researchers claim that ocean acidification may reduce marine biodiversity on a global scale.

PERSONAL RESPONSIBILITY

In the previous paragraphs, we have explored how humans have had a negative impact on the environment. As individuals, we can make ethical and sustainable choices in many aspects of our daily lives to help reduce the negative impact that human

activity has on the environment. For example, you could use public transportation rather than private, use less water and electricity, buy products from environmentally responsible companies, recycle and much more.

Freediving is no exception, and we can adopt practices so as to freedive in an ethical and sustainable way. This will allow you to enjoy this wonderful activity in an environmentally responsible way without damaging the marine environment and the organisms that live there. In the following section, you can read more about how to freedive in a way that protects and conserves the wonderful places you visit during your freediving career.

Before you dive:

- *Choose a responsible Diving Center.* Environmentally responsible Diving Centers use correct anchoring methods that don't damage the seabed (such as fixed moorings instead of traditional anchors that can cause serious damage to seagrass meadows and coral reefs), carefully manage the pollution and waste caused by their boats and sites, always employ experienced guides to accompany you on your dives and explain the rules and codes of conduct you must adhere to when diving during the pre-dive briefing.
- *Learn more about the local environment.*



Increase your own naturalistic awareness and knowledge of the environmental and ecological characteristics of the places you are visiting to help you behave in a correct and responsible manner. This will also improve your understanding of the culture, customs and habits of the marine life, enabling you to better respect the populations that await you in these beautiful underwater habitats.

During your dives:

- **Be aware of your swimming style.** When you perform a turn-up after descending along the guide rope, or at any point when turning during the dive, be careful not to hit your body against the seabed and the organisms that inhabit it, taking particular care of your long and bulky fins. If you are swimming on a sandy seabed, try to avoid agitating the sediment as this can damage life forms nearby.
- **Use the guide rope correctly.** If you are using a guide rope that reaches the sea floor, check that the weight is positioned on a sandy or rocky surface and is not damaging the organisms on the seabed. If you are using a hanging guide rope (that doesn't touch the bottom), make sure that the current or swell doesn't move the weight onto the sea floor, rocky walls or any organisms that grow on the seabed (such as

gorgonians or noble pen shells).

- **Respect all marine life.** Never touch marine organisms; this can cause a fatal shock to them and in some cases can also be dangerous to you. Avoid chasing, disturbing or frightening the organisms around you, always keeping a respectful distance. If you have to pause near the seabed, make sure you hold onto a part of the bottom where no life forms are present.
- **Don't feed the fish.** Never feed the fish; as well as being potentially harmful and toxic for them, this modifies their normal behavior and creates imbalances in the food chain.
- **Never remove organisms from their habitat.** Never take living or dead aquatic organisms away from their environment.
- **Don't litter.** Litter can release harmful toxic substances into the marine environment and some organisms may mistake them for food, as in the case of plastic bags, and suffocate. If possible, collect any litter you find during your dives and throw it into an appropriate trash container when you return to the surface.

In a nutshell, always act as you would want others to act. Don't give credence to the idea that "it's only me doing this, so it can't do too much damage". Instead, bring about the change you want to see: be a responsible and sustainable diver and act as you want



others to act. This is the only way that you and others can continue to enjoy the extraordinary beauty and experiences of the underwater world for a long time to come.

SUMMARY

Having reached the end of this course, you have learned some useful information to help you understand how to explore this wonderful underwater world. We have discussed how, as freedivers, we are guests in an environment in which we don't belong, and how the practices we have learned during the course will help prevent it from being damaged. Now the real adventure begins, giving you the opportunity to explore new countries and different cultures, socializing with other people who share your passion for the underwater world. Remember that this is only the first step along the road to becoming a freediver, and that when you put all your new skills into practice and continue your training with the next SNSI Freediving

Courses, you will learn how to achieve the calm and relaxed frame of mind required to freedive in deep waters, fully aware of yourself and the environment around you, which is gained only through experience.

This is only the start of your adventure, and it is up to you to make it last as long as possible. There are no limits: the more you dive, the more you will enjoy yourself, and the more opportunities you and your friends will have to share the amazing experiences of freediving.

The adventure starts now, so Dive Up Your Life!



CHAPTER 4: STUDY GUIDE



1. Cold water dives take place below which temperature?
 - ☐ 19°C (66°F).
 - ☐ 21°C (70°F).
 - ☐ 29°C (84°F).
2. Waves are caused by the wind blowing on the surface of the water.
 - ☐ True.
 - ☐ False.
3. Currents are caused by many factors including seabed topography and tides.
 - ☐ True.
 - ☐ False.
4. Which factors affect the distribution of marine organisms?
 - ☐ Light.
 - ☐ Waves and currents.
 - ☐ Both.
5. Why are seagrass meadows so important?
 - ☐ They shelter many organisms.
 - ☐ They are useful to anchor boats.
 - ☐ They diminish the force of currents.
6. Where do coral reefs usually develop?
 - ☐ In the tropics.
 - ☐ Above 30 meters (100 ft) depth.
 - ☐ Both.
7. Eutrophication can damage the environment because it causes hypoxia.
 - ☐ True.
 - ☐ False.
8. Why are invasive species dangerous?
 - ☐ They compete with local species.
 - ☐ They don't have natural predators.
 - ☐ Both.



Once you have finished this course,
you are ready for the next adventure:

The SNSI Advanced Freediver Course.

Visit the SNSI website or ask your SNSI Freediving Instructor for more information.

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PART 2: ADVANCED FREEDIVER COURSE



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A stylized, handwritten signature of Pipin Ferreras in white ink.

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CHAPTER 5

SAFETY EQUIPMENT



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CHAPTER 5

As you have learned in the *SNSI Freediver* course, when you perform deep freedives you must always use a guide rope. This is a reference point that will help you reach your desired depth, enable you to descend vertically in a straight line without wasting energy, and most importantly allow you to surface safely and easily. Moreover, your buddy can use the guide rope to track your dive and intervene promptly if necessary.

In this chapter we will explore how to tension the guide rope and how to ensure it is always within reach, regardless of the environmental conditions. On completion of this chapter you will know how to hold the guide rope, how to weight it correctly and how to attach it to the surface buoy. You will also learn how to use and prepare a safety lanyard.



THE GUIDE ROPE

Weighting

First of all, the guide rope must be weighted correctly. To do this, you need to know whether the guide rope needs to reach the bottom or if it can remain suspended in the water. The first situation usually arises when beginning the dive from the shore, as the guide rope needs to reach the bottom to create a point of reference throughout the duration of the dive, not just when descending and surfacing. In this case, the guide rope must be weighted more heavily as it needs to support the weight of the divers when they are holding onto the buoy at the surface. In fact, if there is a strong current forcing the divers away, the weight may plow across the bottom and cause the buoy to drift on the surface. This can cause serious harm to the marine ecosystem, damaging any sessile organisms (those attached to the seabed) that the weight accidentally comes into contact with. Furthermore, if the weight drifts and the buoy changes position, the freedive becomes more dangerous as it may result in



deeper water than intended or in the middle of a busy shipping lane, or even simply further away from the point of entry which makes returning to land difficult.

The above situations do not apply when diving from a boat. In this case, the reference point on the surface is the boat itself, which flies the dive flag. When diving from a boat, two ropes are attached to the buoy, one to connect the buoy to the boat and the other leading down under the water and acting as the guide rope. In this situation, the weight on the guide



rope has the simple purpose of keeping the rope taut and vertical, so less weight is needed.

To weight the guide rope you can use normal lead weights; these are usually heavier (2-3 kg / 4-7 lbs) than those worn on the weight belt meaning the freediver can use fewer actual weights. To position the weights you can use a normal weight belt, making sure that the quick-release function is locked and tie a knot at the end of the belt. However, it is better to use a special belt which has been specifically designed for this purpose; these belts don't have quick-release functions and therefore offer a more secure attachment to the guide rope. To attach the guide rope to the weights you can use the bowline knot described later in this chapter.

Bottom plate

During this *SNSI Advanced Freediver* course, you will dive to greater depths than you are used to. As such, it is very important that you learn how to establish the planned depth for each for each dive. To this end, a specific marker is positioned at the desired depth. This is a circular plate made of plastic, steel or aluminum that measures few tens of centimeters (4-10 inches) wide and less than a centimeter (0.5 inches) thick. The bottom plate also has other advantages: it reduces the risk of hitting your head or shoulders against the guide



rope weights or the seabed itself, and prevents the karabiner of the safety lanyard, described in more detail below, from getting caught on the knot on the weight belt when beginning the ascent back to the surface.

Knots

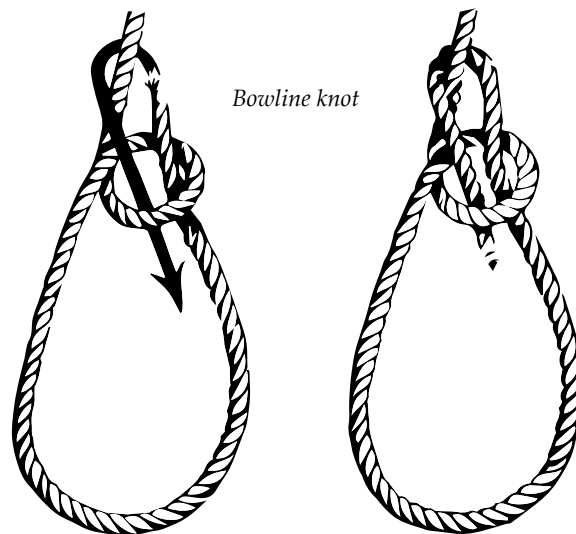
It is important to learn how to join the ropes securely or to attach them to objects such as the weights or the buoy. There are countless knots, all used for different purposes. For your aquatic activities, you need to learn three simple knots: the bowline knot, the square knot and the clove hitch.

Before we look at the individual knots, here are a few definitions of the elements of a knot:

- **Live** (also called working or running) **end**: this is the active part of the rope used when tying the knot.
- **Standing end**: this is the other end of the rope; it is generally under load or fixed to something, and is usually very long.
- **Turn**: when the live end is passed around the standing end to create a loop. Overhand turns are when the live end goes over the standing end, while underhand turns are when it goes under.
- **Eye**: this is the hole created after making a turn.
- **Bight**: a loop where the live end runs parallel to the standing end but in the opposite direction.

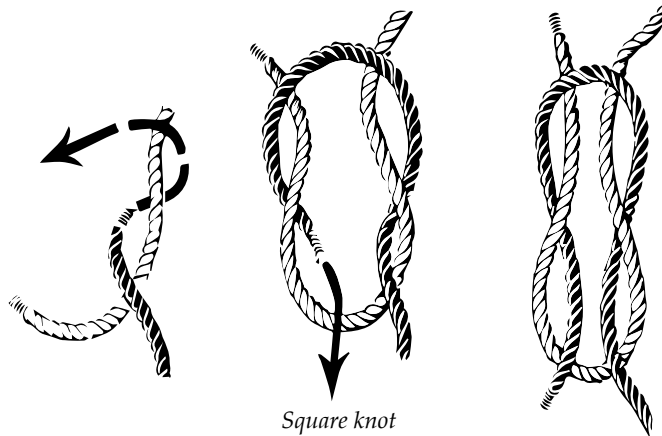
Your SNSI Freediving Instructor will help you learn how to tie these simple but useful knots.

The **Bowline** is a loop knot used to create a loop in the end of a rope, which can then be used to join to another rope. However, the knot is more commonly used to attach the rope to an object such as the tie-in loop on the weight belt. The main advantage of this knot is that it is very easy to untie even after being subjected to heavy loads (for example when the buoy has been buffeted up and down by the waves). This knot is tied in four simple stages: 1) create an eye in the rope by making an overhand turn (so passing the



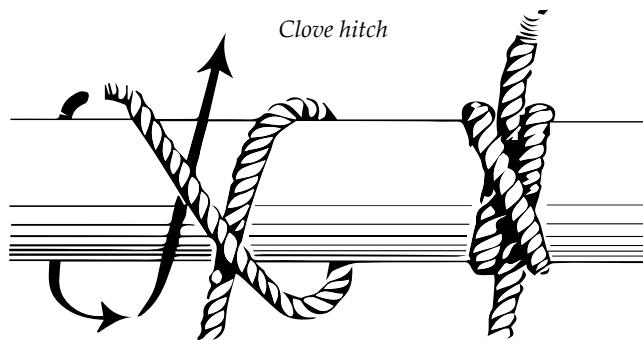
live end over the standing end); 2) pass the live end through the eye (from the bottom up); 3) pass the live end behind the standing end; 4) pass the live end back through the eye and pull.

The **Square Knot** (also known as the **Reef Knot**) is a joining knot that can be used to link two ropes. In a diving context, it may be used to attach the buoy line to the boat line in order to keep the buoy a certain distance away from the boat. This knot is tied in four simple stages: 1) Create a bight in rope one; 2) lay the live end of rope two across the bight (or curve) of rope one; 3) pass the live end of rope two underneath the bight; 4) make a bight in rope two, laying the live end of rope one across the bight and passing it underneath to complete the knot.



The **Clove Hitch** is a very simple knot that can be used when the rope is taut. This knot will enable you to tighten the guide rope correctly when the weight is on the floor, or to extend the guide rope to the correct length when the weight is suspended. This knot is tied in two simple stages:

1) Make an underhand loop around the object you wish to attach the rope to; 2) make an overhand loop with the live end.



SAFETY LANYARD

The safety lanyard is designed to keep you within close proximity of the guide rope, so that as you descend or ascend along it you will be able to maintain direction and not get too far away from the rope itself. Moreover, in an emergency your buddy will be able to



find you quickly and intervene promptly.

The safety lanyard is a Nylon or Cordura sling fastened to the wrist or ankle with an adjustable buckle or a very strong Velcro fastener equipped with a D-ring. The D-ring is connected to a sling (or stainless steel wire) measuring around one yard, the other end of which is equipped with a wide karabiner that can easily run up and down the guide rope. When you fin downwards, it is best to keep the safety lanyard attached to your wrist. However, if you are performing a free immersion, it is best to attach the lanyard to the ankle in order to keep your hands free and enable broader arm movements without getting caught on the karabiner running along the guide rope. During practice dives in open water, get your buddy to help you to move the safety lanyard into the most comfortable position possible before carrying out the exercise your instructor has outlined.

In later *SNSI Freediving* courses, you will learn that it is also possible to attach the safety lanyard at the waist using a specific belt. For safety reasons, it is not recommended to attach the lanyard to the weight belt because if you need to remove the weight belt in an emergency, you risk losing contact with the guide rope. For example, this position is useful when learning to freedive without fins as you will need your arms and legs free to frog kick.



AQUATIC EXERCISES

Frog kicks. Place your arms on a float, hold your head out of the water and look ahead. Move forward by only using your legs. Begin with your legs stretched out behind you and then bring your heels to your backside, keeping the knees together and bending them towards the bottom of the pool. When the legs are fully bent, move your heels so they are level with your sides and position your feet at right angles, with the toes pointing out. Make a circular motion with the legs to extend them back out behind you, feet together. Be careful never to let the knees come more than shoulder width apart. Use the full momentum of each kick before beginning the next one.

Underwater breaststroke. Lie on your stomach near the edge of the pool. Raise your legs, place your feet on the wall and push away from the edge of the pool. Point your head down and arch your back slightly to descend below the water surface. Glide through the water with your



Frog Kick



Underwater Frog Kick





arms stretched out in front, with the palm of one hand over the back of the other and keeping the elbows together. Tuck your chin into your chest, keeping your ears below your arms in order to achieve the most hydrodynamic position possible and to stay near the bottom when swimming. When the momentum from your push-off is coming to an end, perform a breaststroke stroke. Part your hands, pushing them so that they come alongside your thighs and using the momentum to propel you through the water. When this momentum ends, make a frog kick and at the same time extend your arms out in front of you, keeping the arms as close as possible to the body to reduce water resistance. Keep your head down with your chin tucked against your chest during each phase of the stroke.

Dynamic apnea without fins. Lie in the water and float with your face down, trying to find a position where you can relax all your muscles. Position yourself near the edge of the pool, facing in the direction of your dynamic apnea. Perform a preparatory breathing cycle and hold your breath! Raise your legs, place your feet on the wall and push away from the edge of the pool. Point your head down and arch your back slightly to descend below the water surface. When the momentum of the push-off comes to an end, begin to swim using the underwater breaststroke and frog kick, beginning with breaststroke arms. Remember to keep your chin tucked into your chest and to use the full

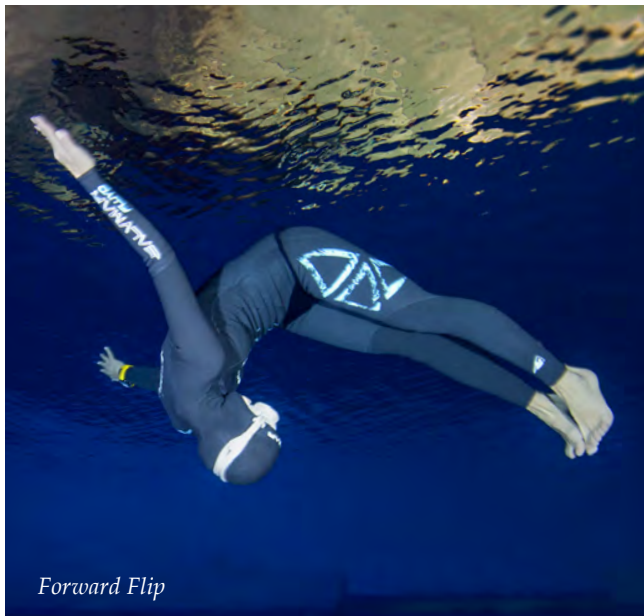
momentum of each stroke and kick. Follow the guide rope along the bottom or the line on the bottom of the pool.

Arm strokes. Position yourself vertically in the water, taking care to keep your legs perfectly straight and close together. Position your elbows at ninety degrees and tuck them into your chest, keeping the upper part of your arm close to your body and the forearms in front of you. Keep your palms facing down and move the forearms out and then in, rotating the palm slightly to “capture” as much water as possible. As you move your arms out, rotate the palm outwards, then as they come back in, rotate the palm inwards. This technique will allow you to maintain your position perfectly.

Leg-kicks. *Frog kick:* From a vertical position, bend your arms and keep your hands out of the water. Perform a frog kick to float, remembering to bend the ankles and keep the feet at a right angle to your legs. Be careful not to bob in the water: the water level should always be just below your shoulders. *Alternating kick:* From the same position as the previous exercise, alternate moving each leg. Push inwardly from the outside, so that as one leg pushes and moves in, the other is in the recovery phase and so moves out.

Complete strokes. Make each stroke with the legs and arms at the same time, first with the frog kick and then with the alternating kick.

Forward Flip. Descend a meter or so below the water using your preferred technique. Adopt a vertical position with your legs straight and together. With your arms extended alongside your body and your palms facing forward, bring your arms straight above your head, keeping them in front of your body, and at the same time roll your head forward to tuck your chin into your chest. Bring the arms back to the starting position, keeping them straight and position them alongside your body. Remember to keep the palms



Forward Flip

parallel to the arm movements. Perform these two movements to rotate your body at least three or four times. Relax your abdominal and leg muscles; your entire body should follow the movement of your chest as your arms do the work.

Backwards Flip. Descend a meter or so below the water using your preferred technique. Adopt a vertical position with your legs straight and together. With your arms extended above your head and the palms facing forward, bring your arms down in front of your



Backwards Flip



body and bring them to your side, at the same time roll your head back, tilting your neck towards your back. Bring the arms back to the starting position, keeping them straight and position them alongside your body. Remember to keep the palms parallel to the arm movements. Perform these two movements to rotate your body at least three or four times. Relax your abdominal and leg muscles; your entire body should follow the movement of your chest as your arms do the work.

Surface dive with the arms. Attach the safety lanyard then lie on your stomach with your snorkel on and your arms stretched out on the surface of the water in front of you. Push your arms towards your feet, positioning them alongside your body with your elbows bent, then immediately bring them above your head, keeping them straight and in front of your body. Tuck your chin into your chest and lower your shoulders. As your body bends downwards and your legs come out of the water, keep your legs vertical above your body. Repeat the first movement with your arms, pushing them towards your feet and keep them alongside your body; this final movement will take you completely under the water. Be careful to perform these movements at a safe distance from the guide rope to prevent getting tangled in the safety lanyard.

Two-legged surface dive. With the safety lanyard attached, lie on your stomach with your snorkel on and your arms relaxed towards the bottom. Put your

legs together, bring your heels towards your backside and bend your knees (keeping them together), then at the same time tuck your chin into your chest and lower your shoulders. When your heels are near your backside, extend your legs and push them out of the water, trying to keep the arms and legs in a line perpendicular to the water surface. As the weight of your legs pushes you downwards, start kicking as soon as you feel your fins enter the water. Be careful to perform these movements at a safe distance from the guide rope to prevent from getting tangled in the safety lanyard.

One-legged surface dive. The previous exercise can also be performed using one leg. This will help to save energy and use less oxygen. Lie on your stomach with your snorkel on and your arms relaxed, pointing down. Bend one leg, bring the heel towards your backside and bend the knee, then at the same time tuck your chin into your chest and lower your shoulders. When the heel is close to your backside, extend the leg out of the water. Try to keep your leg movement perpendicular to the surface of the water and in line with your arms. The other leg stays still and follows the movement of your body; when the weight of the raised leg pushes you downwards, the other leg will be dragged under the water. Begin to kick when both fins are in the water.

Turn-up and Ascending. When you reach your desired depth, it is important to change course before



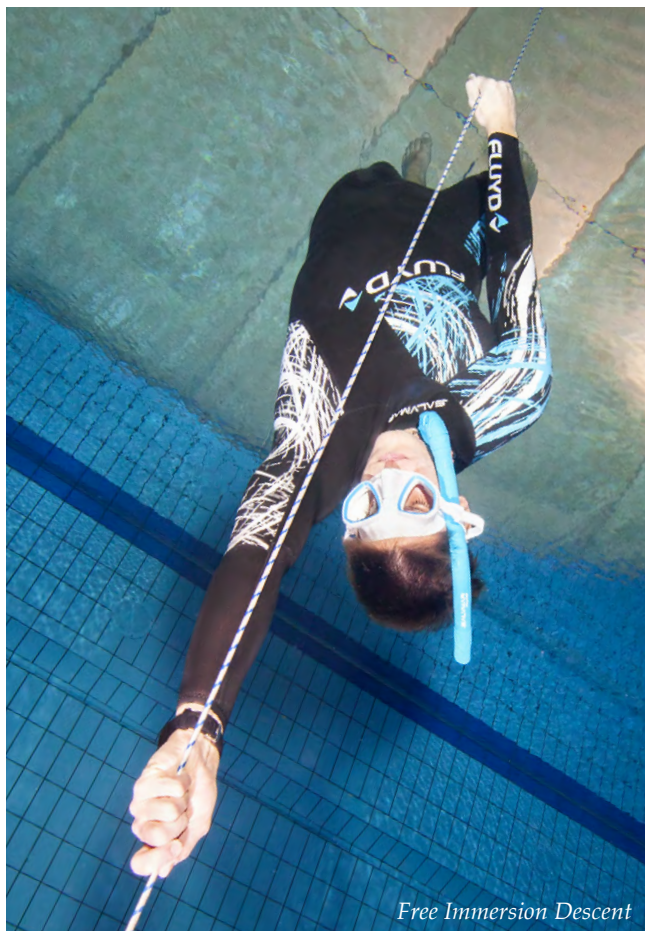


One-legged surface dive

returning to the surface. This maneuver must be as relaxed as possible to avoid wasting energy and using too much oxygen. When you reach the marker that signals your desired depth, gently grasp the guide rope and let the momentum pull your body downwards. Your body will then rotate the hand that is holding the rope. This allows gravity and inertia to bring you back to a vertical position with your head up, enabling you to conserve energy that can be used to surface in a relaxed manner. Before beginning to surface, check that the safety lanyard isn't caught on the bottom plate or the weights, make sure that your position is parallel to the guide rope and ensure that it is a safe distance away so as to be in easy reach but not present an obstacle.

Free Immersion Descent. You can also descend using just the strength of your arms, without using your fins. Hold on to the guide rope with one hand and pull yourself downwards, keeping your head facing down and looking at the rope. When the arm holding the rope is fully extended, extend the other arm down and grasp the rope. Repeat this movement to reach the desired depth. When you perform this movement, attach the safety lanyard to your ankle to keep your arms free and enable you to extend the arms completely between movements.



*Free Immersion Descent*

SUMMARY

This chapter has taught you how to prepare and manage your safety equipment. This will make you more independent and self-aware when organizing your freediving sessions and will help you to become a reliable diving buddy.

CHAPTER 5: STUDY GUIDE

1. The guide rope is essential because it enables you to:
 - ☐ Pull on it with your arms in an emergency.
 - ☐ Descend and surface in a straight line.
 - ☐ Keep the buoy anchored to the bottom.
2. The weight:
 - ☐ Can be placed on the seabed.
 - ☐ Can be suspended in the water.
 - ☐ Both.
3. The bottom plate should be positioned:
 - ☐ Above the weight.
 - ☐ On the seabed.
 - ☐ Two-thirds of the way down the guide rope.
4. The standing end is the part of the rope that is used to tie a knot.
 - ☐ True.
 - ☐ False.
5. The bowline knot:
 - ☐ Is a joining knot.
 - ☐ Is a stopper knot.
 - ☐ Is a loop knot.
6. The square knot:
 - ☐ Is a joining knot.
 - ☐ Is a stopper knot.
 - ☐ Is a loop knot.



7. The clove hitch:

- ☐ Joins two ropes.
- ☐ Can be used to attach the guide rope when weighted.
- ☐ Both.

8. The safety lanyard is designed to:

- ☐ Keep you attached to the guide rope.
- ☐ Keep you attached to your buddy.
- ☐ Attach the guide rope to the buoy.





CHAPTER 6

ADVANCED BREATHING



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CHAPTER 6

BREATHING

CHAPTER 6

In the *SNSI Freediver* course you learned how to increase total lung capacity by consciously controlling your respiratory muscles. As you read this chapter, you will understand how to add even more air to your lungs and use 100% of your lung capacity.

First, let's review the breathing techniques you have learned so far. The breathing cycle begins with diaphragmatic breathing to fill the lower third of the lungs with air; this part of the lung is responsible for most of the gaseous exchange in the body. For proper diaphragmatic breathing, you need to push the

abdomen muscles outwards and lower the diaphragm at the same time. When you have filled the abdominal section completely, continue to bring air into the central area of the lungs, filling the thorax region. To do this, continue to inhale while expanding the ribcage up and out. At the end of this inhalation process, you will have used around 70-80% of your lung capacity.

We will now look at how we can “pack” even more air in order to maximize the use of our total lung capacity.

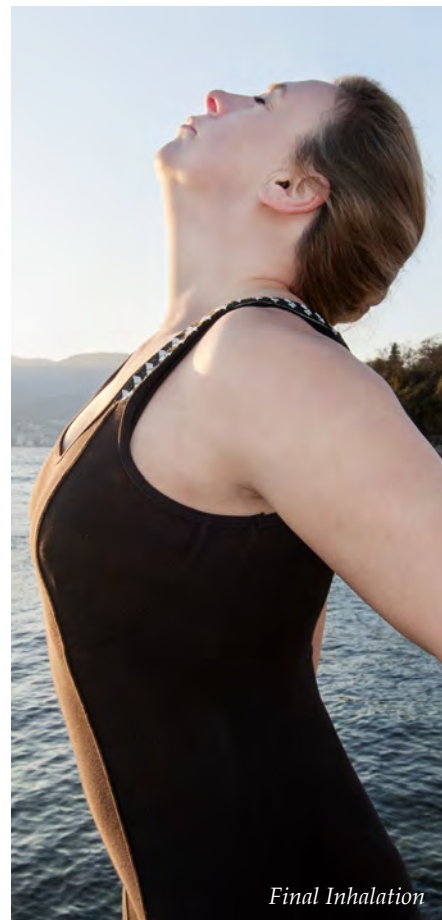


SUB-CLAVICULAR BREATHING

Sub-clavicular breathing is a type of shallow breathing that only utilizes the upper third of our lungs. Sub-clavicular breathing also uses the neck and the trachea to increase the volume of air we are able to inhale. Although this type of breathing is not very effective for efficient gaseous exchange, there are two reasons why it is important to learn to use it to prepare for deep-water freedives. On the one hand, adding more air to our lungs enables us to hold more oxygen in our body, which then moves into the part of the lung that processes the gaseous exchange so that the oxygen can be transported around the blood while we hold our breath. However, the main reason for using this breathing technique is to make more air available for when we need to equalize our mask and ears. Remember that as you descend, the air in your lungs is compressed by the hydrostatic pressure around you.

During the *SNSI Advanced Freediver* course, you will dive to 20 meters / 66 feet depth, where the pressure around you is 3 atmospheres / 44.1 psi; this reduces the air in your lungs by a third.

Let's look at the following example to better understand why this breathing technique is so important. If you manage to inhale 4.5 liters (0.16 ft³) of air, or 75% of your lung capacity, purely through diaphragmatic and thoracic breathing, by performing sub-clavicular breathing as well you will be able to inhale around 6 liters (0.21 ft³) of air. At 20 meters / 66 feet depth, the air in your lungs will increase from a volume of 1.5 liters / 0.05 ft³ (one third of 4.5 liters/ 0.16 ft³) to 2 liters / 0.07 ft³ (a third of 6 liters / 0.21 ft³). This means you still have half a liter more air in your lungs to use for equalization. Moreover, in the next chapter you will learn how to work out and increase your exact total lung capacity, another essential skill for freediving safely.



Final Inhalation



For correct sub-clavicular breathing, you need to push your shoulders up and back. As you will soon discover, during the last inhalation before the dive and at the apex of the breathing cycle, you will also need to extend your neck, tilting your head back to fully open the airways to allow you to inhale more air.

BREATHING CYCLES

Until now you have combined diaphragmatic and thoracic breathing to prepare for your dives. Now we are going to learn how to achieve the most efficient breathing cycle for freediving, using all three breathing techniques we have looked at so far (diaphragmatic, thoracic and sub-clavicular) in the right order, for the right length of time, and with the correct inspiratory and expiratory volumes.

Preparatory Breathing. Begin with abdominal breathing, inhaling and exhaling a normal volume of air and keeping the abdominal muscles relaxed. During this phase, you are preparing to enable air to flow correctly: you need to relax all the muscles in the body and take the time you need to focus and visualize the final objective. When you have returned to a normal breathing cycle (after a dive, for example), you must spend at least a minute performing normal and relaxing preparatory breathing cycles.

Breathing Sequence. After doing preparatory breathing for at least a minute, begin the breathing

sequence. A normal breathing sequence uses around 70-80% of your lung capacity. When performing the breathing sequence, it is very important to follow these stages in a precise order, beginning with abdominal breathing, moving onto thoracic breathing and then following the same order during exhalation, emptying the lower part of the lungs by the diaphragmatic method then breathing through the chest to empty the central and upper part. It is important to maintain a steady breathing rhythm; each inhalation should last 3-5 seconds, followed by 3-5 seconds of exhalation. You must repeat this procedure for at least two minutes, meaning you will realize around 15 - 20 complete breathing cycles.

Advanced Breathing Sequence. After completing the breathing sequence, begin the advanced breathing sequence. This includes all of the three types of breathing - abdominal, thoracic and sub-clavicular, and utilizes around 90-95% of your lung capacity. The advanced breathing sequence is similar to the normal breathing sequence, but at the end of each inhalation you must remember to inhale extra air into your throat through sub-clavicular breathing. After the inhalation, reverse the order as you would for a normal breathing sequence. Each inhalation should last around 3-5 seconds, followed by 3-5 seconds of exhalation and a pause of at least one second. You must repeat this procedure for at least two minutes, meaning you will make around 15 - 20 complete breathing cycles.



Final Inhalation. After completing the advanced breathing cycles, you are ready to take your final breath before you dive. The aim of this inhalation is to utilize 100% of your lung capacity. At the end of your final advanced breathing sequence, remember to breathe out forcefully in order to remove as much carbon dioxide from your lungs as possible. Once your lungs are empty, your final inhalation has two goals: to bring your oxygen levels to its maximum with a single breath, and to store as much air as possible to use for equalization.

TRAINING YOUR BREATH-HOLD TECHNIQUE

You have already discovered on the *SNSI Freediver* course that there are different ways to train your breath-hold ability, both on land and in the water, and how you don't need to make deep dives to practice. During this course, your instructor will help you to improve your performance by applying the new breathing techniques you have just learned to many of the exercises you have previously practiced.

Important Note. The first time you try these exercises, only do so under the supervision of your SNSI Freediving Instructor. This will assure your safety, as well as providing the opportunity to correct your techniques before you develop bad habits that might affect your performance.



Afterwards, you can repeat these exercises without your instructor, but always do so with your buddy and never on your own.

Exercises - Revision

Timed apnea. Lie face up in a relaxed position with your feet on the ground and legs bent. Complete one full breathing cycle: preparatory breathing, breathing sequence, advanced breathing sequence and final inhalation. *Now hold your breath!* Your instructor will time you to keep track of your performance.

Static apnea. Lie in the water and float with your face down. If you aren't wearing a wetsuit or this doesn't offer you enough buoyancy, you can use a float under your legs. Try to find a comfortable position, relaxing your muscles as much as possible. In this position, complete one full breathing cycle: preparatory breathing, breathing sequence, advanced breathing sequence and final inhalation. *Now hold your breath!* Your buddy will help you during this exercise, so agree on a signaling system for safety. For example, your buddy might signal to you every 15-30 seconds (depending on the scheduled length of the static apnea; the first few times you try, you will aim for 60 seconds and so your buddy will give a signal every 15 seconds, then once you have more experience and are aiming for two minutes of static apnea, your buddy can signal to you every 30 seconds) and you might respond with a gesture, such as a nod of the head or a

hand gesture. One of the most commonly used signals is to raise the index finger.

Dynamic apnea. Lie in the water and float facing down, trying to find a position where you can relax all your muscles. Position yourself near the edge of the pool, facing in the direction of your dynamic apnea. In this position, complete one full breathing cycle: preparatory breathing, breathing sequence and final breathing sequence. *Now hold your breath!* Raise your legs, place your feet on the wall and push away from the edge of the pool. Point your head down and arch your back slightly to glide below the water surface. You can use the flutter kick or dolphin kick for this exercise. Follow the guide rope or the line along the bottom of the pool. Your buddy will track you from the surface, carrying a floatation device in order to offer support or assistance if needed.

Diaphragmatic contractions

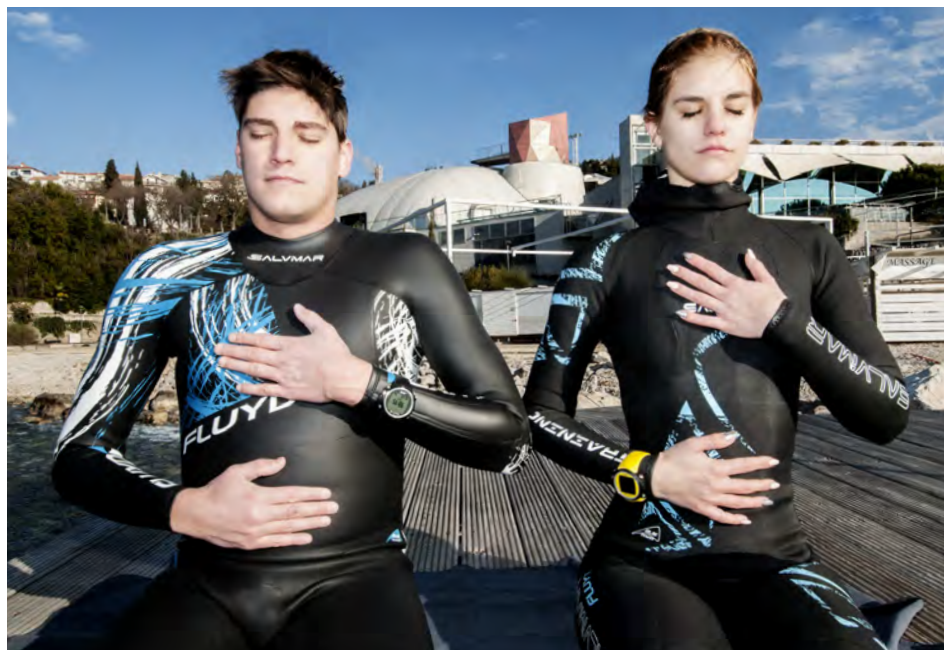
During the *SNSI Freediver* course, you learned how to stop holding your breath as soon as you felt your diaphragm contract. However, at this more advanced level you need to take your awareness of your body and its sensations to the next step. As you know, diaphragmatic contractions are an alarm bell and are one of the most important signals that our body sends during apnea. These contractions are involuntary and are caused by nerve impulses sent from the respiratory center in the brain. As you discovered on the *SNSI*



Freediver course, the breathing reflex occurs when the carbon dioxide levels in our body increase. This increase is perceived by certain receptors located mainly in our carotid arteries (the arteries that carry blood to the brain) and the aorta (the artery that leads away from the heart). The receptors stimulate the neurons in the respiratory center, which in turn sends nerve impulses to the diaphragm to make it contract. This increases the volume of the lungs and enables new air to enter the body. However, as your mouth is closed during apnea, bringing air into the lungs is impossible. Because of this, as the diaphragm contracts you will also feel your epiglottis contract as it is pulled downwards.

To become an advanced freediver, it is essential to learn how and when these reflexes occur and how to recognize them clearly and accurately. It is important to practice the exercises yourself in order to experience the sensations caused by diaphragmatic contractions first hand. You can practice the exercises

on land or in the pool and gradually become familiar with these sensations in a safe environment. By performing specific exercises, you can learn to induce diaphragmatic contractions quite rapidly in a decisive and unmistakable manner. When you carry out these exercises, pay attention not only to the contractions of the diaphragm in your abdomen, but also to the spasms of your epiglottis and the tension in your



thorax, as these sensations are directly caused by the diaphragmatic contractions.

Important Note. Again, your SNSI Freediving Instructor will supervise when you practice these exercises for the first time, offering assistance and thus assuring your safety. Your instructor can also correct your position and make sure you don't develop any bad habits that will affect your performance and safety. *It is essential to be closely monitored whenever you perform these exercises, even when you are practicing without your instructor.* Freediving is always carried out with a buddy, and this is even more important when practicing these exercises as you are pushing your physique to its limits. Only practice these exercises on land or in the pool.

Diaphragmatic contraction exercises

Dry exercise:

Walking apnea. You have already practiced this exercise during the SNSI Freediver course. Now let's see how we can adapt it to focus on diaphragmatic contractions. Sit on a chair in a relaxed position with a straight back. Complete one full breathing cycle: preparatory breathing, breathing sequence, advanced breathing sequence and final inhalation. *Now hold your breath!* Stay in a relaxed position on the chair, continuing to hold your breath. When you feel the first contraction in your diaphragm, stand up and walk in a straight line at a slow and relaxed pace. Continue

to walk until you gain control of your diaphragmatic contractions. Try to take steps that are about the same length as the width of your shoulders. Your instructor and buddy will follow you closely when you are practicing this exercise, in order to offer you assistance if you should require it. They will also count how many steps you manage to take, so you will be able to see a measurable progress from one exercise to the next.

Contraction counting. Same as the previous exercise begin by sitting on a chair in a relaxed position with a straight back. Complete one full breathing cycle: preparatory breathing, breathing sequence, advanced breathing sequence and final inhalation. *Now hold your breath!* Stay in a relaxed position on the chair, continuing to hold your breath. When you feel the first diaphragmatic contraction, signal to your buddy then remain in a relaxed position, continuing to hold your breath until you feel fully comfortable with the diaphragmatic contractions this causes. While you hold your breath, try to count how many diaphragmatic contractions you experience.

Aquatic exercise:

Stimulating diaphragmatic contractions. This exercise aims to rapidly induce diaphragmatic contractions. Swim four pool lengths of freestyle, stopping for 20 seconds between each length. After another 20 seconds, swim a final length of freestyle, trying to breathe as little as possible (taking a maximum





of 2-3 breaths over the length). On reaching the end of the pool, where your buddy is waiting, breathe in deeply and begin to perform a static apnea. You will feel your diaphragm contract in less than half a minute; concentrate until you manage to control the contractions, focusing on the sensation. Your buddy will count during the apnea and will signal to you every 10 seconds; remember to respond with the familiar signal for static apnea.

Dynamic apnea. This exercise is useful to learn how much time you have to return to the surface after the first diaphragmatic contraction. Lie in the water and float face down, trying to find a position where you can relax all your muscles. Position yourself near the edge of the pool, facing in the direction of your dynamic apnea. In this position, complete one full breathing cycle: preparatory breathing, breathing sequence, advanced breathing sequence and final inhalation. **Now hold your breath!** Go underwater and grasp a pre-placed weight, then begin a static apnea on the floor of the pool. Stay in this position until you feel the first diaphragmatic contraction. Signal to your instructor that you are about to move. Let go of the weight and swim using the flutter kick, moving as quickly as possible and following the guide rope or the line along the base of the pool. Continue to swim for as long as you can hold your breath. Remember to swim quickly for the entire exercise and try not to lose speed at the end. Your instructor, and your buddy

when you practice this exercise afterwards, will follow you closely from the surface in order to offer prompt assistance if required.

AQUATIC EXERCISES

Turning. At the end of this *SNSI Advanced Freediver* course, you should be able to complete 35 meters (115 feet) of dynamic apnea with fins. It is therefore very likely that you will need to turn underwater at the end of the first length of the pool to swim in the opposite direction. It is important to learn the correct turning technique to avoid wasting too much energy and to help you achieve your goal of 35 meters (115 feet) more easily. As you approach the edge of the pool, place one hand on the wall, keeping it under the water, and extend the other arm down to your side. From this point there are two methods. For the first method (open turn), bring your knees to your chest and your heels to your backside. Tuck the legs under your body and rotate your torso by 180 degrees to point yourself in the new direction. The second method is called the flip turn and brings the legs over your body. With one hand on the wall of the pool, raise your heels and bring them towards your backside, keeping your knees away from your body. This allows you to rotate 180 degrees without your legs hitting the wall. Both techniques allow you to turn in either direction, depending on the position of

your hands; you must always rotate in the opposite direction to the hand against the wall.

SUMMARY

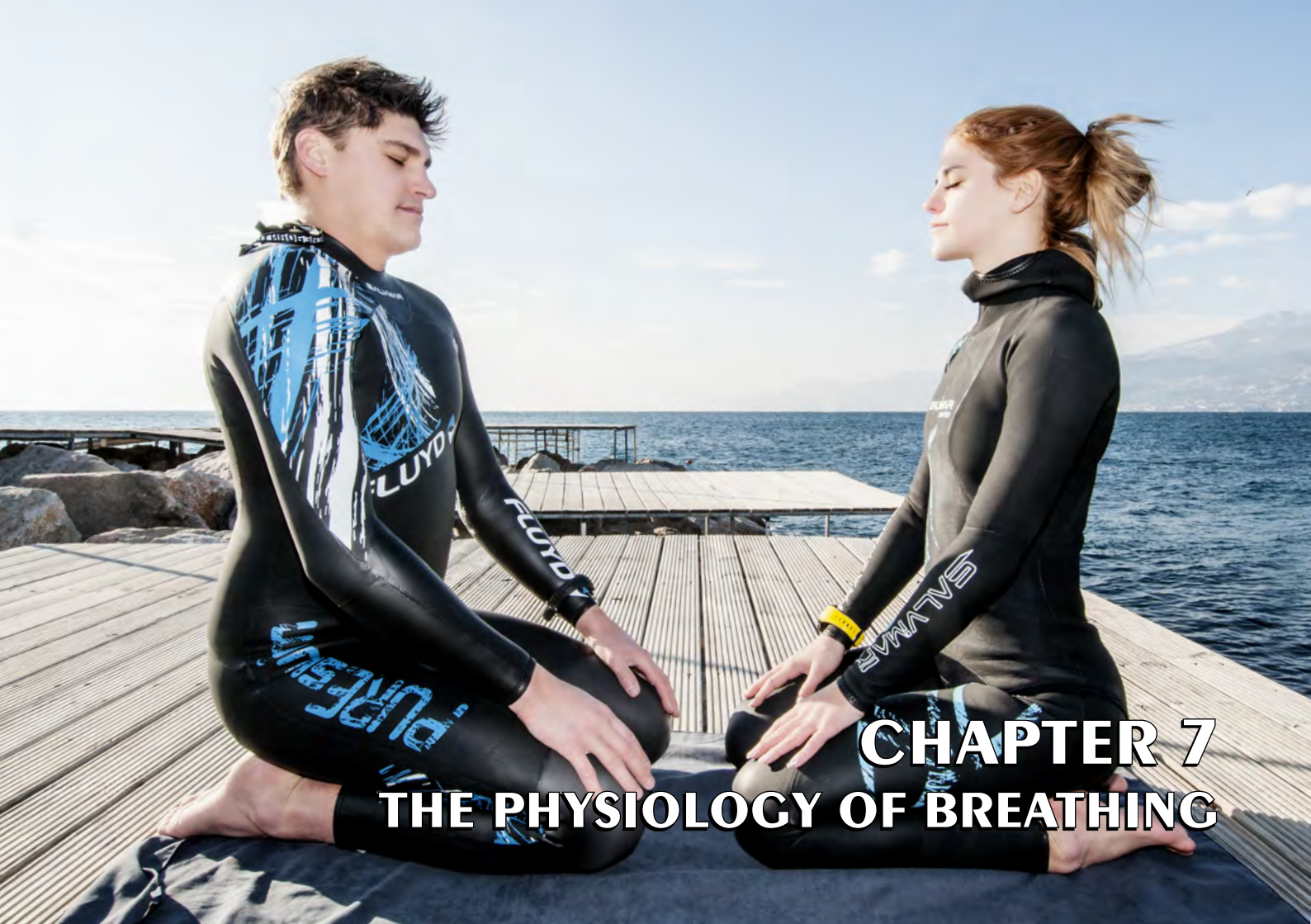
At the end of this chapter, you have increased your awareness of your true breathing potential and are now able to use the full extent of your lung capacity. However, this is not a magic formula that will transform you into an expert freediver and is just one more tool in your toolbox. As you have learned in the *SNSI Freediver* course, becoming a competent freediver requires training, perseverance and determination.



CHAPTER 6 STUDY GUIDE

1. Sub-clavicular breathing:
 - ☐ Is a type of shallow breathing.
 - ☐ Uses the upper third of the lungs.
 - ☐ Both.
2. Sub-clavicular breathing is an efficient way of stimulating gaseous exchange.
 - ☐ True.
 - ☐ False.
3. The advantages of sub-clavicular breathing are that:
 - ☐ It uses the lower third of the lungs and facilitates gaseous exchange.
 - ☐ It facilitates equalization.
 - ☐ Both.
4. Which type of breathing technique should you use when preparing to hold your breath?
 - ☐ Thoracic breathing.
 - ☐ Diaphragmatic breathing.
 - ☐ Both.
5. After holding your breath, preparatory breathing helps to re-establish the right levels of gas in the blood.
 - ☐ True.
 - ☐ False.
6. During the breathing sequence, the inhalation should last for:
 - ☐ 3-5 seconds.
 - ☐ The same length of time as the exhalation.
 - ☐ Both.
7. The normal breathing sequence uses:
 - ☐ 40-50% of your lung capacity.
 - ☐ 70-80% of your lung capacity.
 - ☐ 100% of your lung capacity.
8. The final inhalation uses:
 - ☐ 40-50% of your lung capacity.
 - ☐ 70-80% of your lung capacity.
 - ☐ 100% of your lung capacity.





CHAPTER 7

THE PHYSIOLOGY OF BREATHING



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CHAPTER 7

In the *SNSI Freediver* course you learned about gaseous exchange and what causes the breathing reflex. As part of the *SNSI Advanced Freediver* course, it is important that you understand exactly what is happening inside your body and which physical and physiological mechanisms enable you to live and breathe. Each breath we take uses various organs in our body, all with different shapes and functions but which are ultimately working towards the same objective: to carry oxygen to every single cell in our body and remove the carbon dioxide produced as we metabolize it. Each respiration is divided into various

phases: ventilation, or rather the movement of air from outside our body into our lungs; diffusion, or rather the transfer of the oxygen and carbon dioxide held in our lungs into the blood; and the transportation of oxygen from the lungs to our cells, and carbon dioxide from the cells to our lungs.

VENTILATION

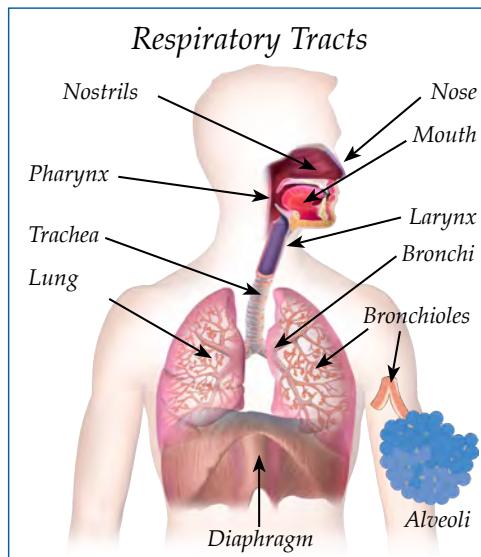
Our respiratory system is made up of the airways (or respiratory tracts), where gases are not exchanged, and the lungs, where gases are moved between the air and



our blood. The airways connect the external environment to our internal body systems and are subdivided into the upper respiratory tracts (nose and mouth, larynx and pharynx) and the lower respiratory tracts (trachea, bronchi and non-respiratory bronchioles), and form our physiological “dead space”. The main purpose of the respiratory tracts is to purify, heat up and humidify the air before it comes into contact with the blood, reducing the risk of toxic substances entering the blood supply and preventing our body from getting too cold. The final part of the respiratory system are the respiratory bronchioles, alveolar ducts and alveoli, where gaseous exchange occurs. The alveoli are tiny sacks that contain the air transported into our bodies via the respiratory tracts, and there are millions of them in each lung. They are formed of a very thin membrane surrounded by a dense network of capillaries. The alveoli and related capillaries form the basic part of the lung.

Pulmonary cavities

Let's take a moment to consider these chambers



and try to give some definitions that will give you a better understanding of some of the concepts we will discuss later. As you saw on the SNSI Freediver course, your breathing, or rather the amount of air you intake into your body, is not always the same, and in fact to improve your freediving performance you are now able to store much more air than you would usually breathe in everyday life.

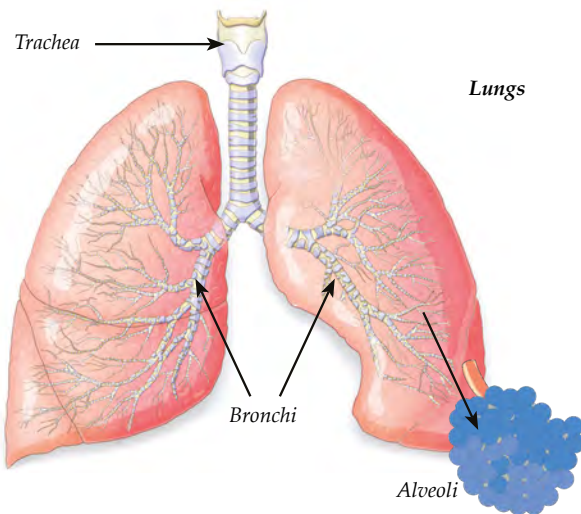
Tidal volume is the amount of air you inhale and exhale during an unforced breath, for example how you might breathe when reading, and is usually around

0.3-0.5 liters / 0.01-0.02 ft³.

Inspiratory reserve volume is the maximum amount of air that you are able to inhale into your lungs through extra force after taking a normal breath (2-3 liters / 0.07-0.11 ft³).

Expiratory reserve volume is the maximum amount of air that you are able to exhale from your lungs through extra force after taking a normal breath (1-1.5 liters / 0.04-0.05 ft³).

Vital capacity is the sum of the tidal volume, inspiratory reserve volume and expiratory reserve



muscles and the respiratory muscles themselves. The thoracic cage (or ribcage) is composed of the ribs which are supported by the spine behind and the sternum in front, and protects our lungs while enabling us to breathe. The main muscles that operate in the breathing process are the diaphragm, a large dome-shaped sheet attached to the inner edge of the lower ribs which separates the thoracic cavity from the abdominal cavity; the muscles between the ribs (intercostal muscles); certain muscles in the neck and the pectoral girdle.

As you have already learned on the *SNSI Freediver* course, the breathing reflex is provoked by the respiratory center in the brain and is activated by the level of carbon dioxide in the arterial blood. As soon as this level rises, the respiratory center uses the

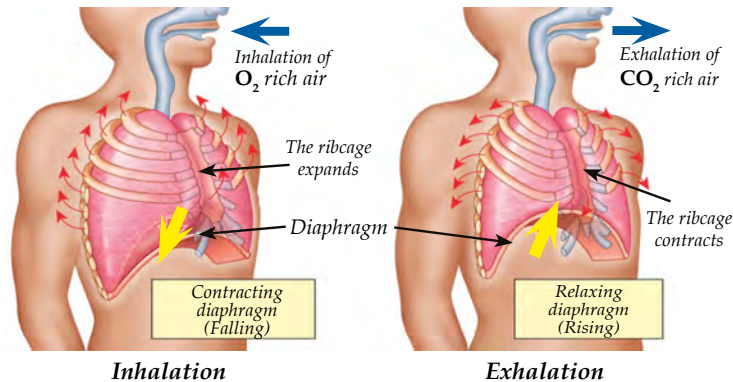
volume (3-5 liters / 0.11-0.18 ft³).

Residual volume is the amount of air left in your lungs after a forced exhalation (1 liter / 0.04 ft³).

Total lung capacity is the sum of your vital capacity and residual volume, and represents the total amount of air you can hold in your body after a forced inhalation.

The respiratory muscles

The neuromuscular system also plays a part in ventilation and is formed of a respiratory center in the brain, the nerves of the breathing



nervous system to activate our breathing muscles. The diaphragm and intercostal muscles vary the volume of the thorax and enable ventilation to occur. Inhalation is an active process. The contraction of the diaphragm pushes the muscle downwards, increasing the volume of the ribcage by extending the length. As the outer intercostal muscles contract, the ribs are pulled upwards and outwards, increasing the volume of the ribcage in a forward/backward direction. These movements increase the volume of the lungs which, according to Boyle's Law, causes the internal pressure to reduce, taking in air from outside through the respiratory tracts. Normal exhalation is a passive movement, resulting from the elastic recoil of the ribcage as the respiratory muscles relax. This reduction in volume pushes air out of the lungs. The diaphragm and outer intercostal muscles are the main muscles used for respiration, but during a forced inhalation or exhalation the inner intercostal muscles and other muscles in the neck that help to move the ribs may also be used.

GAS DIFFUSION

The air movements we have looked at thus far regard air masses. However, when it comes to the alveoli, the transfer is molecular, meaning that single molecules of the respiratory gases contained in the air in lungs are transferred to the capillaries through the

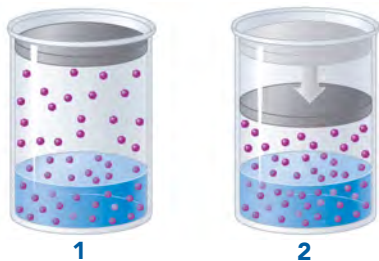
process of diffusion. To understand this phenomenon properly we need to discuss the laws of physics that govern gases.

In the *SNSI Freediver* course we learned about the law of partial pressures (Dalton's Law), which states that the sum of the partial pressures of individual gases in a mix is equal to the pressure of the mix itself. At the end of a complete inhalation, the air in our lungs contains 20.95% oxygen and 78.08% nitrogen, with the remaining percent composed of a mix of other gases, mainly argon, while carbon dioxide makes up just under 0.04%. According to Dalton's Law, at sea level the oxygen inside our lungs exerts a pressure of 159.22 mmHg (0.209 atm or 3.07 psi) while carbon dioxide exerts around 0.304 mmHg (0.0004 atm or 0.006 psi).

Henry's Law

Let's look at another law of physics that governs how gas behaves: Henry's Law. The gas laws you encountered in the *SNSI Freediver* course only apply to gases and mixed gases. However, there are also cases when a gas is present within a liquid, and we know that in certain situations gases dissolve (technically *becoming a solution*) in the liquid: for example, we know that fish process oxygen that has *dissolved* in the water and that all carbonated drinks like soda contain *dissolved* carbon dioxide. Many people find it difficult to understand how gases can dissolve into liquids. To





HENRY'S LAW
"A gas that exerts a certain pressure on the surface of a liquid becomes a solution when its pressure in the liquid is precisely equal to its pressure above the surface of the liquid."

the naked eye, a liquid doesn't appear to have any space for a gas to penetrate, yet we know that gases dissolve in liquid. We can see this every time we put a piece of ice in a carbonated drink. The bubbles that form are carbon dioxide coming out of the liquid. Although we can't see it in its dissolved form, the gas stays in liquid form until something causes it to change out of it. Another important concept is that a gas dissolved in a liquid continues to exert pressure. This pressure inside the liquid is defined as *gas tension*. The scientist William Henry studied how much gas can be absorbed by a liquid and what factors influence this process. His experiments proved that the quantity of a given gas that dissolves in a given liquid at a given temperature depends on the partial pressure of the gas and its affinity with that liquid. According to Henry's Law, temperature and pressure affect how much gas can dissolve in a liquid. As a concrete example, imagine that you have a glass of water that doesn't contain any dissolved gases. The glass is placed in a container

and a vacuum is created around it, meaning there are no gases in contact with the water. If air is inserted into the container and this comes into contact with the water, the molecules of the different gases in the mix begin to penetrate the liquid. The dissolved gas exerts its tension in accordance with Dalton's Law, and each component of the gas exerts its partial tension. The difference between the pressure of gas in contact with the liquid and the tension of the dissolved gas is called the pressure gradient. If this gradient is high, gas is absorbed rapidly by the liquid. However, as the molecules of gas dissolve in the liquid, the gradient diminishes and the molecules dissolve more slowly. The gas will dissolve in the liquid until its tension is equal to the pressure of the gas in contact with the liquid. Although molecules will continue to enter the liquid, the same number will exit from it, meaning they balance each other out and the quantity of dissolved gas does not increase. At this point the liquid is said to be *saturated*. Besides pressure, temperature also affects the absorption of gas in liquids. Heat speeds up the motion of the molecules in a liquid, and this rapid motion leaves less space for the gas molecules. We can see this phenomenon when we boil water. As the water heats up, small air bubbles form which collect on the bottom of the pan. This is caused by the increased motion of the water molecules pushing out the dissolved molecules of air. It is therefore logical that the colder a liquid is, the more gas that can be



dissolved in it. The molecules of a colder liquid move more slowly, creating space for a larger number of gas molecules.

Gaseous exchange

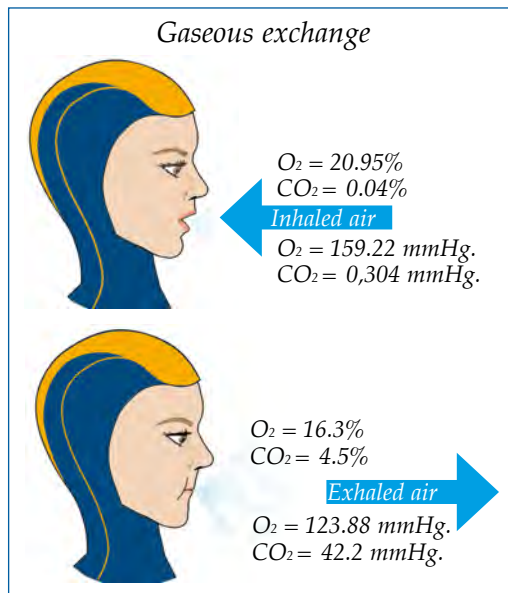
Gaseous exchange occurs thanks to the pressure gradient, or rather the difference between the partial pressure of the respiratory gas (oxygen or carbon dioxide) present in the alveolar air and the partial tension of the same gas in the blood. Henry's Law states that, like temperature, gas moves from areas of high pressure to areas of low pressure, following the pressure gradient.

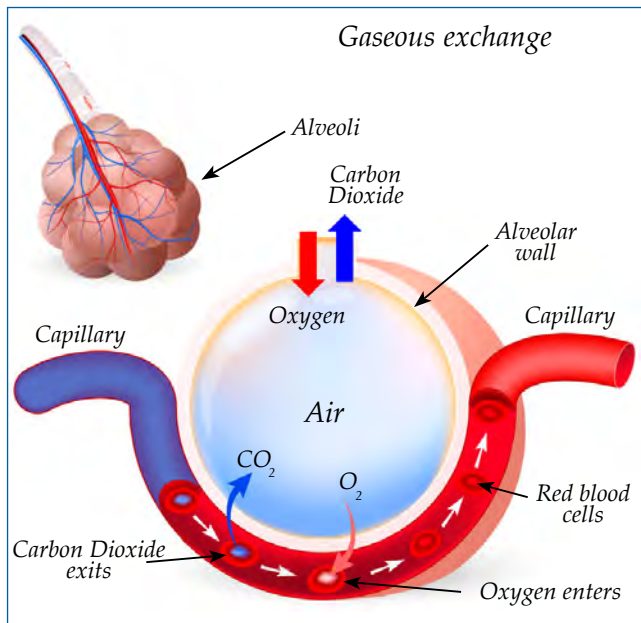
The blood circulating in the alveolar capillaries reaches the lungs from the periphery of the body. As it has already delivered oxygen to the cells, this blood has low oxygen levels and high carbon dioxide levels. As such, the partial pressure of oxygen in the blood is less than the partial pressure in the alveolar air, while the partial pressure of carbon dioxide is greater. There is therefore a difference in pressure, the gradient, between

the gases contained in the blood which reaches the alveoli and the gases contained in the air inside the alveoli themselves. As such, a certain amount of oxygen transfers from the alveoli to the blood, while a certain amount of carbon dioxide transfers from the blood to the alveolar air.

This exchange can occur thanks to the specific structure of the alveoli and their capillaries. The walls of the alveoli are very thin and are formed of a single layer of cells. These are surrounded by a very high number of capillaries that often come into contact with one another in the alveolar wall. The capillaries are also very small, meaning that only one red blood cell can pass through at a time. Red blood cells carry oxygen and contain a substance called hemoglobin, which is able to chemically bind itself to many types of gas. Hemoglobin has a close affinity with oxygen, and in fact most of the oxygen that is transferred from the alveoli into the capillaries binds with it very quickly.

When blood releases carbon dioxide and collects oxygen, it transforms from venous blood





to arterial blood. Now let's look at the difference between these two types of blood and the route they take through our bodies to transport carbon dioxide and oxygen respectively.

GAS TRANSPORTATION

The cardiovascular system transports oxygen, nutrients and waste products around the body. It is formed of the heart, which maintains blood circulation;

the *blood vessels* (arteries, veins and capillaries), which contain the circulating blood; and the blood itself which carries the dissolved oxygen, the nutrients and the waste products.

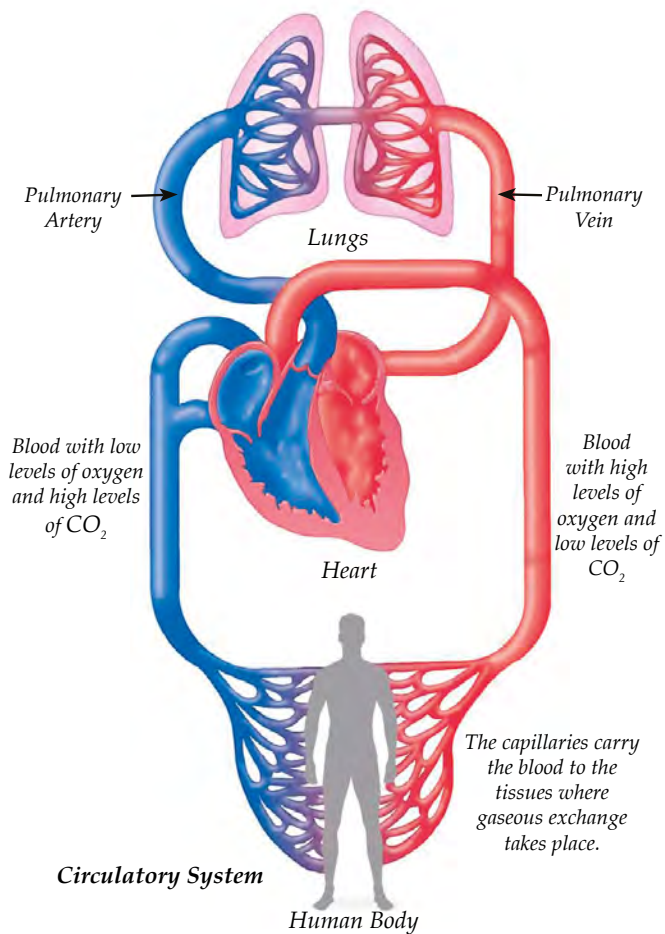
The *heart* is a hollow involuntary muscle, meaning it works without our conscious control, which contracts rhythmically and acts as a pressure and suction pump, pushing and drawing blood to and from the different parts of the body.

The heart is located in the thoracic cavity between the lungs and rests on the diaphragm which separates it from the abdominal cavity. This is composed of four cavities: two upper cavities, known as atria, and two lower cavities, known as ventricles. The heart is also divided lengthwise: the right side of the heart is formed of the right atrium and right ventricle, while the left side of the heart is formed of the left atrium and left ventricle.

The two sides do not communicate with one another, but each atrium communicates with the corresponding ventricle below through a one-way valve, the tricuspid (right) and mitral (left) heart valves. The atria receive the blood from the periphery of the body, with blood coming from the tissues entering the right atrium and blood coming from the lungs entering the left atrium.

The ventricles push the blood out of the lungs and pump it into the blood vessels. The right ventricle pushes the blood from the right atrium to the lungs,





while the left ventricle pushes the blood from the left atrium to the tissues.

The atria have thinner walls than the ventricles and dilate as blood flows into them while simultaneously pushing it through the valves and into the ventricles. At this point the ventricles contract and pump the blood away. At the end of the phase when the ventricles contract (*systole*), the heart muscle relaxes and the two cavities extend to allow the chambers to fill with blood (*diastole*).

The *blood vessels* are divided into categories based on their position in relation to the heart and their direction of circulation. The ventricles push the blood towards the periphery of the body through the *arteries*, while the atria receive the blood through the *veins*. Therefore we can deduce that the blood flowing through the arteries has a centrifugal, or outwards, motion, while the blood in the veins has a centripetal, or inwards, motion.

As they get further away from the heart, the arteries branch out significantly; these narrower arteries are known as *arterioles*. The arterioles then branch into even narrower vessels called *arterial capillaries*, and these flow into the *venous capillaries* which in turn flow into the larger veins. The *capillaries* are where the arterial and venous systems meet. Blood vessels can also be distinguished by their difference in structure. In the arteries, the outer wall is formed of muscular tissue which is able to contract to support the pumping

action of the heart and modify the width of the lumen (the hollow channel inside the artery), affecting the speed of the blood flow. The veins contain special valves which prevent gravity from causing the blood to flow in the opposite direction between one heart beat and the next.

The two blood circuits

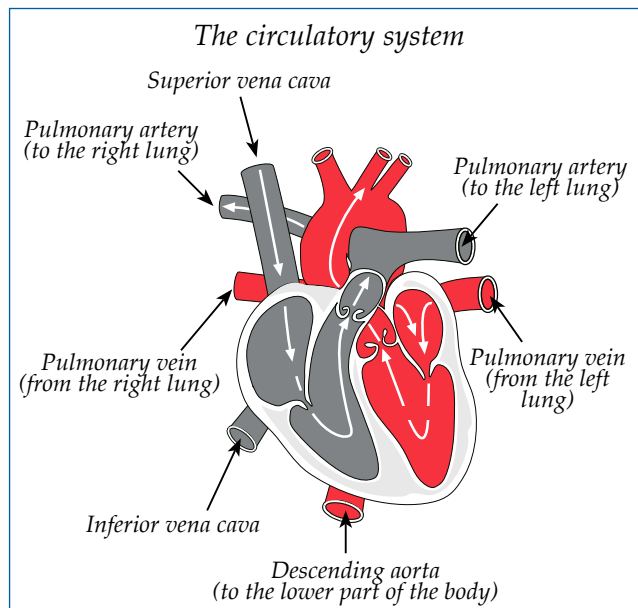
Although they are in direct contact with one another, the right and left sides of the heart are responsible for two different circulatory systems, the large circuit and the small circuit.

The *large circuit* begins from the left ventricle and pushes oxygenated blood through the aorta to every part of the body through a vast network of arteries and arterioles. Thanks to the elastic arterial walls, the blood pumped by the contracting ventricle is carried at a speed of 9 meters (30 feet) per second. In the arterioles, the speed reduces to one millimeter per second to facilitate the gaseous exchange between the blood and the cells of the tissues.

On reaching the cells, the arterial blood releases its nutrients and oxygen and collects the waste substances. It then flows into the veins which carry it to the right atrium, where it passes through the tricuspid valve into the right ventricle to enter the *small circuit* (or pulmonary circulatory system).

As mentioned above, the blood is now carrying the waste products, including carbon dioxide, and is

pushed through the pulmonary artery to the lungs, where it splits into numerous different branches leading into a dense network of microscopic arterioles that cover the walls of the pulmonary alveoli. After becoming oxygenated and releasing the carbon dioxide into the pulmonary capillaries, the blood enters the veins. These become increasingly wide until separating into the four pulmonary veins which carry the blood to the left atrium. Here, the blood moves

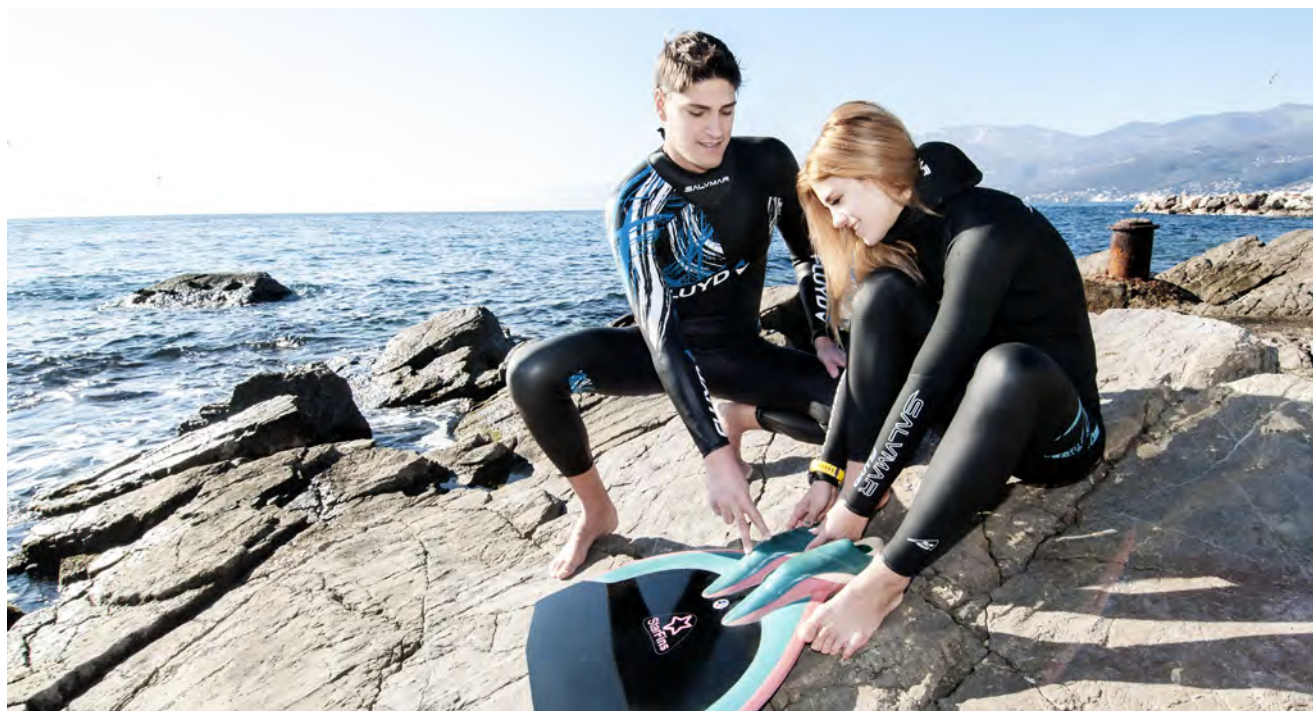


into the left ventricle and the *large circuit* begins again.

As you have just discovered, the claim that “arterial blood carries lots of oxygen while venous blood carries lots of carbon dioxide” is not wholly accurate. In fact, it applies to the entire circulatory system with two main exceptions: the pulmonary artery and the pulmonary veins. In fact, on the *small circuit*, the

pulmonary artery transports the blood with high levels of carbon dioxide from the heart to the lungs where it is oxygenated, then the pulmonary veins carry the oxygenated blood to the heart.

We have seen how oxygen (and carbon dioxide in the opposite direction) is transferred from the outside environment to the individual cells in our body. Here,



oxygen diffuses from the peripheral capillaries to individual cells through a diffusion process in much the same way as it transfers between the alveolar air and the blood in the capillaries of the alveolar walls.

When oxygen enters the cells, cellular respiration occurs; this is a metabolic process which, thanks to the presence of the oxygen itself, burns nutrients such as sugar and fatty acids to produce energy.

We will explore this concept in more detail in subsequent levels of the *SNSI Freediving* program when we discuss different training techniques.

AQUATIC EXERCISES

Surfacing with a partially flooded mask. Perform a surface dive, fin to the bottom and perform a turn-up. Now allow a little water to enter your mask, pulling the upper silicone rim of the mask away from your forehead slightly. Fin up the guide rope then on reaching the surface, empty your mask as you learned on the SNSI Freediver course, pulling the mask away

from your face with both hands.

Surfacing without a mask. Perform a surface dive, fin to the bottom and perform a turn-up. Now take off your mask and put it around your neck. Fin up the guide rope then on reaching the surface, put your mask back on. Position the strap on the nape of your neck and bring your mask to your face, ensuring that no part of your clothing or hair becomes caught under the silicone of the mask.

SUMMARY

In this chapter you have learned what happens in your body on each and every breath, gaining an understanding of the body's physiological processes and the organs behind them. This will increase your knowledge as an advanced freediver, enabling you to dive with complete self-awareness of your body and the mechanisms that freediving provokes, and consequently discovering your personal limits and how to manage them safely.





CHAPTER 7: STUDY GUIDE

1. Respiration is made up of
 - ☐ 2 phases.
 - ☐ 3 phases.
 - ☐ 4 phases.
2. Gaseous exchange takes place:
 - ☐ In the lower respiratory tracts.
 - ☐ In the trachea.
 - ☐ In the alveoli.
3. Total lung capacity is the sum of:
 - ☐ The inspiratory and expiratory reserve volumes.
 - ☐ The tidal volume and residual volume.
 - ☐ The vital capacity and residual volume.
4. As you inhale:
 - ☐ The diaphragm contracts and the intercostal muscles relax.
 - ☐ The diaphragm contracts and the intercostal muscles contract.
 - ☐ The diaphragm relaxes and the intercostal muscles contract.
5. During diffusion, oxygen moves:
 - ☐ From the lungs to the blood.
 - ☐ From the blood to the lungs.
 - ☐ In both directions.
6. The right atrium receives:
 - ☐ Blood from the tissues.
 - ☐ Blood from the lungs.
 - ☐ Oxygenated blood.
7. Diastole means the contraction of the ventricles.
 - ☐ True.
 - ☐ False.
8. The arteries:
 - ☐ Always carry high levels of oxygen.
 - ☐ Always carry blood in a centrifugal (outwards) motion.
 - ☐ Both.



CHAPTER 8

PHYSIOLOGICAL ADAPTATIONS



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Although humans have adapted to live on land, we can nonetheless recognize our marine ancestry. All known life forms alive today evolved from the first organisms that developed in the so-called “primordial soup”, the ocean that covered the Earth around 3 billion years ago. The physiological mechanisms and adaptations that our body undergoes when we go underwater are so pronounced and effective that some academics have put forward the hypothesis that humans evolved, or at least spent some of their evolutionary history, in an underwater environment, the so-called “the aquatic monkey theory”.

Humans are aquatic animals not only from a phylogenetic perspective (which refers to the origin of the species as a whole), but also in terms of ontogenesis (meaning the origin of each individual). In fact, the fetus develops in an aquatic environment, namely the amniotic fluid inside the mother's womb. This is why for the first six months of their lives, newborn babies are entirely comfortable underwater. Newborns do not swallow water, instinctively closing their mouths and, most importantly, their epiglottis, which separates the digestive and respiratory systems by sealing the

trachea. They also keep their eyes open and are able to coordinate their arms and legs to move short distances in the water. The adaptations and behaviors we see in newborn babies originate from the diving reflex. This phenomenon has been extensively studied in marine mammals which have adapted to swim underwater, such as seals, whales and dolphins; these animals have a particularly well-developed diving reflex, but the mechanism is in fact present in all mammals, including humans, and it is this reflex that enables us to make deep freedives.

Now let's try to gain a better understanding of what the diving reflex is and what physiological adaptations it induces in our bodies.

THE DIVING REFLEX

During your *SNSI Freediver* course, you probably noticed that you were able to hold your breath longer when performing static apnea in a pool than you could on dry land. The reason for this improved performance is the so-called diving reflex, which kicks in when we are immersed in water and mainly causes changes to our cardiovascular systems, such as a slower heart rate, peripheral vasoconstriction and higher blood pressure. In particular, the diving reflex is sparked when cold water comes into contact with our face; immersing other parts of the body in water does not provoke the same

physiological response. This contact stimulates the thermal receptors located on the forehead, around the eye-sockets and on the cheekbones which are connected predominantly to the trigeminal and vagus nerves. These receptors then stimulate the nerve centers which control our heart rate, blood pressure and the vascular tone of our blood vessels. The purpose of these physiological changes is to protect our body in what it considers to be a new and hostile environment. In fact, these alterations help us to conserve oxygen, in particular from our extremities, in order to redirect it to our vital organs (brain, heart and liver), as well as to reduce heat loss resulting from contact with water.

Bradycardia, the result of stimulation of the vagus nerve, causes a 10% to 50% reduction in heart rate in humans and an even more dramatic response in certain marine mammals, dropping to 80% to 90% in seals. It also reduces the amount of oxygen required by the entire body. Peripheral vasoconstriction reduces capillary diameter and limits blood flow to the extremities; hands and feet are the first to be affected, followed by the arms and legs. These effects enable the body to conserve the right amount of oxygen for the heart and brain, at the expense of organs which are more resistant to ischemia.

Another effect of the diving reflex is spleen contraction, triggered when the body's oxygen

levels fall. In fact, during immersion the spleen continues to contract and releases more red blood cells which, despite the fact that partial pressure gradient is limited, enables the blood to transfer more oxygen molecules from the lungs into our circulation, making them available for metabolic functions. Furthermore, this greater number of red blood cells significantly aids recovery after freediving, quickly restoring normal blood oxygen levels to the body.

The speed and intensity of the diving reflex depend on the temperature of the water and physical fitness. Frequent freediving in water accelerates the onset of the diving reflex and amplifies its effects.

THE BLOOD SHIFT

When freediving was first practiced as a recreational sport, the physical limit of freediving was widely discussed. In fact, many doctors believed that the human body would not be able to support the pressure of the water beyond certain depths. Many freedivers, including the Italian Enzo Maiorca, often dived against medical advice, knowing that according to medical opinion at the time, they were putting their lives in danger.

However, all of these freedivers succeeded in their endeavors and today athletes reach depths that are 4 or 5 times greater than those believed



possible in the past. These achievements are made possible by another physical mechanism called the *blood shift*.

As a concept, the doctors' beliefs were not wrong. In fact, they believed that as if we were to descend deeper underwater, the water pressure would compress the air in the respiratory tracts, in turn reducing the volume of the lungs and causing the ribcage to collapse. During the descent, the total lung capacity, or rather the amount of air held inside the lungs after a forced inhalation, reduces and on reaching a certain depth attains its residual volume, namely the amount of air that can never be expelled from the lungs even by a forced exhalation. Theoretically, continuing to descend beyond this point could cause serious lung injuries. As such, the depth at which total lung capacity is reduced to the residual volume would therefore be the maximum depth a diver could reach. Given that on average, the residual volume is around a quarter of total lung capacity, the pressure of 4 atmosphere (58.8 psi bar) reached at 30 meters (99 feet) depth would reduce the volume of the lungs to their residual volume.

In practice however, freediving champions have proven that this limit doesn't check out. This is because of peripheral vasoconstriction, when a large quantity of blood in our arms and legs is redirected back to our chest, mainly in the pulmonary artery. This causes blood pressure to rise

and the pulmonary capillaries in the alveolar walls to thicken, consequently reducing the air spaces in the alveoli themselves and drastically reducing the residual volume. To put it simply, the reduction of the volume of air in the lungs is equalized by the greater quantity of blood in the walls of the alveoli.

However, this physiological adaptation can cause problems for freedivers when diving or surfacing.

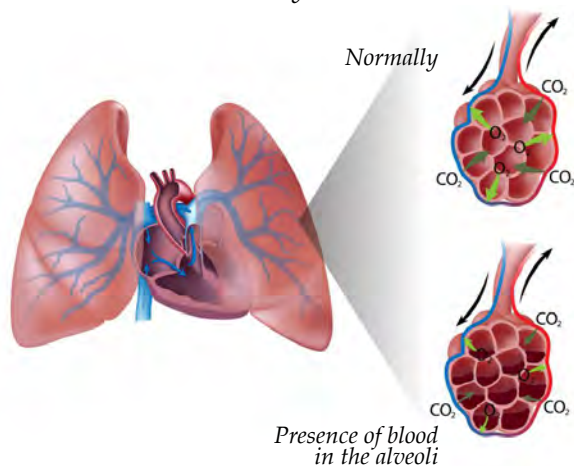
Hemoptysis

Hemoptysis is the presence of blood in the respiratory tract and some divers experience this during their freedives. The causes behind this problem are not completely clear, although the issue has been widely debated in the medical field and there are currently two schools of thought which have assigned two different physiological causes to the phenomenon: *pulmonary edema* and *lung overexpansion*.

Pulmonary edema

As you have just seen, as the depth of a dive increases, a large quantity of blood is recalled from the periphery of the body to our chest to prevent it from collapsing. This causes the lumen (the inside space) of the pulmonary capillaries to increase and results in a sharp increase in blood pressure. These processes cause the walls of the capillaries to extend in response to the modifications of the *blood shift*. Consequently, the cells that form the walls of the

Pulmonary Edema



capillaries become slightly further apart, increasing the permeability of the wall itself. When freediving, the ambient pressure increases proportionally to the depth, and the air in our lungs adapts to the increased pressure by reducing its volume. In this way, the intrathoracic pressure is maintained at the same level as the hydrostatic pressure until total lung capacity is reduced to the residual volume. The volume cannot be reduced below this limit because of the rigidity of the thorax, and consequently this creates a slight depression in the lungs that, combined with the greater permeability of the

cell wall and the higher blood pressure, can cause blood to pass from the circulatory system to the lungs, resulting in pulmonary edema. The first sign of pulmonary edema is hemoptysis, which can be recognized by the traces of blood in the saliva. If this occurs, you must end the diving session immediately and not dive again that day. In serious cases of pulmonary edema, divers may have difficulty breathing (shortness of breath), rattling lungs and a persistent cough with frothy, pink or blood-streaked saliva. In these cases, pure oxygen should be given as first aid and the diver should be hospitalized immediately.

As explained above, pulmonary edema is possible when a depression is created in the lungs following an ineffective *blood shift*. As we know, this phenomenon is a physiological adaptation that our body undergoes in response to an increase in ambient pressure, and so we need to allow adequate time for the process to occur correctly. For deep freedives, it is important to warm up well before each session and reach the maximum depth of the dive gradually. If you have not dived for a long time, it is also recommended to make multiple dives before diving to your maximum level.

Lung overexpansion

When resurfacing from a dive, the reduction in water pressure causes an increase in the volume of



the air inside your body cavities, including your lungs (Boyle's Law). It can take a few hours for the amount of blood that has been transferred to the thoracic cavity during the *blood shift* phenomenon to be redistributed around the body after diving. This means that when resurfacing from a dive, the pulmonary capillaries are still "swollen" with blood and consequently prevent the alveoli from expanding completely in response to the reduction in ambient pressure. In other words, the volume of your lungs immediately after a freedive is smaller than it was when you began the dive, but the amount of air in your lungs is still the same as the amount you breathed in before the dive. This overexpansion of the lungs can create micro-lacerations in the alveolar wall, causing a small amount of blood to enter the lungs (thus explaining the flecks of blood in the saliva which indicate hemoptysis).



However, lung overexpansion can also cause serious damage to the lungs, such as pulmonary barotrauma (also known as lung over-pressure injury) when the lung walls rupture as gas enters the circulatory system. If the lung tissue tears and air bubbles enter the bloodstream, the diver may suffer a pulmonary embolism, which occurs when one or more air bubbles block the blood supply to any part of the body, including the brain. The symptoms of pulmonary embolism can be slight, such as numbness in the limbs or temporary loss of sight, speech and hearing, or may cause the diver to lose consciousness.

This scenario is unlikely to occur at the depths reached during this *SNSI Advanced Freediver* course, but it may be more of a risk as you dive to deeper depths during more advanced courses. Consequently, it is essential that you learn to surface with your glottis open,

enabling any excess air to escape from your lungs without damaging them. The symptoms of a lung overexpansion injury are immediate and include difficulty breathing (shortness of breath), coughing and blood in the mouth and throat. The seriousness of these symptoms depends on the extent of the damage to the lung tissue. In this scenario, the first response should be to administer pure oxygen at ambient pressure. The injured diver must then be taken to hospital for tests and to assess the extent of the damage.

Diuresis

Diuresis is also affected by the *blood shift*. In fact, high blood pressure in the thorax and heart can result in the production of diuretic hormones that aim to reduce the build-up of pressure.

This can result in the diver becoming dehydrated, particularly given that during your diving sessions you will be spending a long time in the water. It is important to remember to drink enough before entering the water and to continue to hydrate throughout the diving session.

AQUATIC EXERCISES

Easing a cramp on the surface. On the surface, ask your buddy to simulate a cramped calf muscle. Get him to grasp the buoy with one hand and hold



him heel with the other, bringing the affected leg parallel to the water surface and placing the heel on your thigh. Place one hand over the knee to prevent it from bending then with your other hand, push the fin blade towards your buddy. After a few moments, massage the affected calf with the hand that was on the knee.

Surfacing using the arms. If you experience cramp when making a freedive descent, you need to be able to surface despite the pain in your leg. One way of doing this is to swim to the surface using breaststroke arms. Perform a surface dive, fin to the bottom and perform a turn-up. Now simulate a cramp and return to the surface, staying close to



the guide rope and doing underwater breaststroke. Remember to pause between each stroke to fully utilize the momentum. Obviously, try not to move your legs or fins when surfacing.

Surfacing with a single fin. Another method of returning to the surface with a cramp is to use the free immersion technique. Perform a surface dive, fin to the bottom and perform a turn-up. Now take off one fin and lay it on the bottom of the pool. Grasp the guide rope with one hand and pull upwards, looking at the rope. When the arm holding onto the guide rope is fully extended along your body, extend the other arm towards the surface and grasp the rope. Repeat this movement to reach the surface. On reaching the surface, breathe, perform a correct breathing sequence then descend using the free immersion technique to retrieve your fin. Put your fin back on and return to the surface by whichever technique you prefer.

Loss of Motor Control and Blackout Management. If you notice that your buddy or a nearby diver is showing the first signs and symptoms of LMC or seems to have lost consciousness, the first thing to do is to call for help. Next, approach the unconscious diver and roll him onto his back, facing up. The first step is to improve him buoyancy, so unbuckle the weight belt. Remove his mask and, if necessary, his snorkel. Position yourself behind the unconscious diver, placing both hands on the sides

of his head with your palms pressed against his ears, placing your middle or ring fingers below his lower jaw (be careful not to press the other fingers against the soft skin below the chin). Apply slight pressure to enable you to tilt his head backwards to open the airways. Blow energetically on his mouth and repeat: "Breathe! Breathe! Breathe!". If he does not respond, you must begin to administer rescue breaths. Position yourself behind the unconscious diver, placing both hands on the sides of his head with your palms pressed against his ears, placing your middle or ring fingers below his lower jaw (be careful not to press the other fingers against the soft skin below the chin). Apply slight pressure to enable you to tilt his head backwards to open the airways. Begin by giving two rescue breaths to attempt to interrupt the laryngospasm and kick-start the breathing reflex. If this doesn't work, you need to drag the unconscious diver to the shore, blowing in the airways every 5 seconds. Count one thousand and one, one thousand and two, one thousand and three, one thousand and four, administer a rescue breath, then repeat until reaching the shore.

Shallow Water Blackout Rescue. If you notice signs of Shallow Water Blackout while watching your buddy, swim towards him and approach him from behind his right side. Position your left hand below his left armpit and use your right hand to unbuckle the weight belt. Grasp the injured diver under the



armpits and bring him to the surface, keeping your arms extended above you so his body is above yours to make you more hydrodynamic and to stop anything from getting in the way of your fins. Call for help as soon as you reach the surface. Remove his mask and, if necessary, his snorkel. Position yourself behind the unconscious diver, placing both hands on the sides of his head with your palms pressed against his ears, placing your middle or ring fingers below his lower jaw (be careful not to press the other fingers against the soft skin below the chin). Apply slight pressure to enable you to tilt his head backwards to open the airways. Blow energetically on his mouth and repeat: "Breathe! Breathe! Breathe!"

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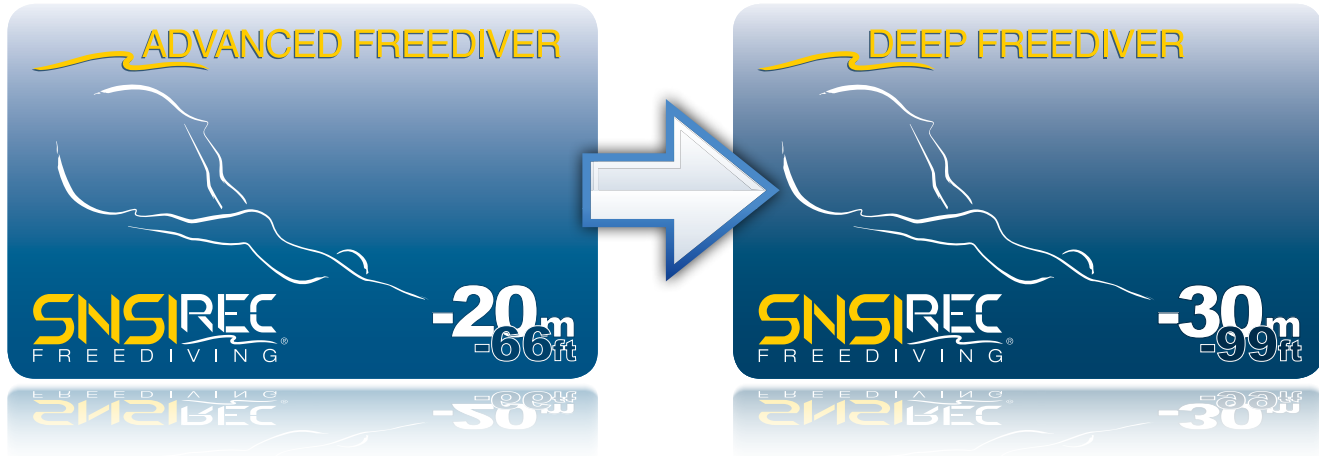
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SUMMARY

In this chapter you have learned about the physiological adaptations that your body initiates each time you dive underwater while holding your breath, enabling you to dive further and improve your freediving performance. You have also learned the effects these adaptations have on your body and the symptoms and conditions these can cause. You now know how to act and how to plan your diving sessions correctly to create a safe environment for your freedives.





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CHAPTER 8: STUDY GUIDE

1. The diving reflex kicks in:
 - ☐ When you hold your breath.
 - ☐ When your face comes into contact with water.
 - ☐ When your body goes underwater.
2. The diving reflex:
 - ☐ Slows the heartbeat.
 - ☐ Lowers blood pressure.
 - ☐ Reduces breathing frequency.
3. Peripheral vasoconstriction is useful as it helps us to:
 - ☐ Use less oxygen.
 - ☐ Reduce heat loss.
 - ☐ Both.
4. When the spleen contracts, it:
 - ☐ Reduces oxygen consumption.
 - ☐ Produces more red blood cells.
 - ☐ Increases oxygen consumption.
5. The theoretical diving limit is linked to:
 - ☐ The collapse of the lungs.
 - ☐ Partial pressure of oxygen.
 - ☐ Both.
6. Hemoptysis is:
 - ☐ The presence of blood in the respiratory tracts.
 - ☐ The collapse of the lungs.
 - ☐ A pulmonary embolism.



- 7.** What occurs after a pulmonary edema?
- ☐ Blood moves from the alveolar capillaries to the lung.
 - ☐ The saliva is flecked with blood.
 - ☐ Both.
- 8.** Lung overexpansion is caused by:
- ☐ The permeability of the alveolar wall.
 - ☐ The blood shift.
 - ☐ The oxygen concentration.



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