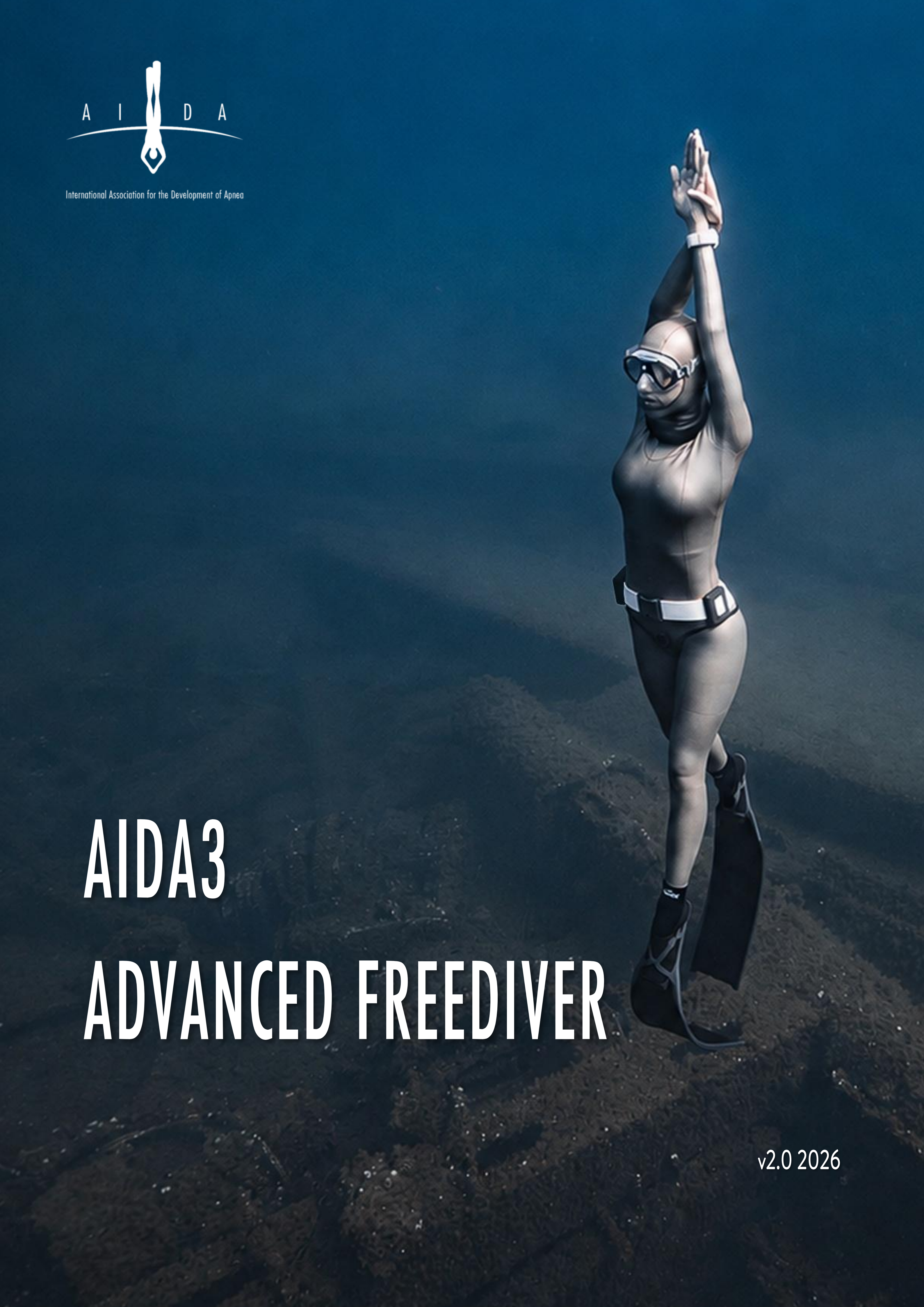


A I D A

International Association for the Development of Apnea

AIDA3
ADVANCED FREEDIVER

v2.0 2026

CONTENTS

CHAPTER 1

1 INTRODUCTION TO AIDA3

In your AIDA1 and AIDA2 courses, you experienced a detailed introduction to modern freediving. These courses focus mainly on safety by learning and applying sound freediving techniques. If you have understood and were able to apply these fundamental freedive-skills, the required performances for your AIDA1 & 2 certifications were safely in your reach, without extra training, and certainly without stretching your personal limits.

In this AIDA3 course, you will now go one step beyond. You will learn how to train as a freediver and bring your freediving to the next level, beyond the basics. Systematically and safely, you will expand your capabilities as a freediver, but remember:

In freediving, performance must follow from a correct approach and proper technique—never from pushing beyond your limits.

1.1 Information about this course

Continuing your AIDA education

The ***AIDA3 Advanced Freediver course*** builds on the foundations developed in AIDA1 and AIDA2, and represents the next step of the ***AIDA Education Program*** (Figure 2). It marks the transition from learning the basic principles of freediving to understanding how to train, progress, and refine your skills in a systematic way.

As freediving continues to evolve, the AIDA Education Program evolves with it. Educational materials are regularly revised, adapted, and developed to reflect current knowledge, practical experience, competition practice, and relevant medical research. This ongoing process is one of the reasons why AIDA has been recognized as a worldwide reference point for freediving education since its inception in 1992.

Prerequisites

To enroll in the AIDA3 Course you must:

- Be 18 years of age or older (16 years with parent or guardian consent)
- Have completed the ***AIDA2 Freediver course*** or passed ***AIDA Crossover Evaluation***
- Have completed the ***AIDA Medical Statement*** (in countries where it is applicable)
- Have completed the ***AIDA Liability Release Form*** (in countries where it is applicable)

Course structure

During this AIDA3 Course, your instructor will conduct:

- Min. 3 theory lessons
- Min. 2 pool sessions
- Min. 4 open water sessions

The content of this manual covers the 3 above-mentioned theory lessons conducted by your AIDA Instructor. The manual does not entirely replace the face-to-face theory lessons: You discuss your understanding of freedive theory based on the Knowledge Reviews at the end of every chapter. Also, a written exam after the third theory lesson has to be passed. After having finalized the exam, your AIDA Instructor will discuss the exam answers with you in order to fill-in every single missing point of knowledge. Hence, you will be able to successfully understand all requirements of the AIDA3 Advanced Freediver course.

1.2 Paperwork

In some countries, before starting your course, you will need to provide some important paperwork to your instructor: this helps to make sure you are fit for and aware of the risks of freediving.

AIDA crossover evaluation

If you already have a certification from a freediving organization other than AIDA, you might not need to start your education with a beginner course when signing up with AIDA for the first time. Your AIDA Instructor will evaluate your knowledge of theory and skills in pool and open water which will allow for an appropriate identification of your level.

Also, if you are an experienced freediver, spearfisher or freediving athlete without any previous certification, your AIDA Instructor may be able to permit you to skip the beginner level course, once your freediving skills and knowledge have undergone an evaluation and have been proven to meet the requirements of the respective course.

To enroll in this AIDA3 Course, you will need to demonstrate the same skills required for the AIDA2 certification:

- Static (STA): > 2 min
- Dynamic with fins (DYNB): > 40m
- Constant Weight (CWTB): 12-20m
- Free Immersion (FIM) technique demonstration
- Buddying and rescue technique in all disciplines

These skills must be properly demonstrated through the application of sound technique. For example, it is not sufficient to simply reach −12 m; the dive must be performed with an efficient duck dive, proper line orientation, streamlined body position, effective finning and equalization, a controlled and safe bottom turn, and efficient use of buoyancy during the ascent.

If necessary, your AIDA Instructor will assess your skills and knowledge during a minimum of:

- 1 Classroom session
- 1 Pool / confined water session
- 1 Open water session

This evaluation requires a minimum of one day. Once you have sufficiently mastered all required skills taught in AIDA2 you are allowed to enroll in the AIDA3 Course. If you are not yet able to comfortably pass this evaluation while demonstrating the required skills and knowledge, there is no need to worry. Following the evaluation, and prior to the start of the AIDA3 course, your AIDA Instructor will be able to offer additional training sessions. Neither the evaluation itself, nor the extra training sessions are part of the AIDA3 course.

If you come from a freediving agency different than AIDA you can refer to the crossover equivalency table to find your bearings (Figure 1).

Medical statement (where applicable)

The ***AIDA Medical Statement*** outlines potential conditions that may prevent you from safely practicing freediving. In countries where this form is required, if all questions are answered “NO”, then you are ready to begin your freediving journey. Any answer marked “YES” automatically requires written medical clearance from a qualified physician before the start of your course. For this purpose, please ask your doctor to complete the designated section of the form.

Be honest about your medical condition, including any issues not explicitly listed in the document, such as previous minor surgeries or mild cases of asthma. Your examining physician aims to obtain a comprehensive overview of your condition in order to support your safe participation in freediving.

If you are travelling to a remote island to attend your AIDA course, please ensure that you have all required documentation with you before departure. When required, the AIDA Medical Statement must be completed, signed, and submitted to your AIDA Instructor at the beginning of the course.

Please note that in some countries, medical self-declarations are not legally valid, and instructors may even be prohibited from collecting such information. In some cases, you may be required to undergo a medical examination and obtain a sport fitness certificate from a qualified physician before the course.

Liability release (where applicable)

In many countries, you will have to hand in a signed ***AIDA Liability Release Form*** before any in-water activity. This form highlights that freediving is a safe activity, provided that all guidelines and instructions given by your instructors are properly followed. Over more than 25 years of instruction, AIDA courses have maintained an exemplary safety record, and it is our intention to uphold this standard. This waiver confirms that you are aware of the potential risks associated with freediving and that you understand your personal responsibility as a fundamental component of safe practice.

A I D A

CROSS-AGENCY EQUIVALENCY

AIDA	PADI	SSI	MOLCHANOVS	FII	PFI	APNEA ACADEMY	RAID	CMAS
AIDA 1	Basic	Basic / Pool	Lap 1	Level 1 Pool	Basic	Indoor	—	Discovery
AIDA 2	Freediver	Freediver	Wave 1	Level 1	Freediver	First Level	Open Water	1 Star
AIDA 3	Advanced	Advanced	Wave 2	Level 2	Intermediate	Second Level	Advanced	2 Star
AIDA 4	Master	Performance	Wave 3	Level 3	Advanced	Third Level	Master	3 Star
AIDA INSTRUCTOR	Freediver Instructor	Instructor	Wave 2 Instructor	Level 1 Instructor	Freediver Instructor	Instructor	Open Water Instructor	1 Star Instructor

PROGRESSION

AIDA REFERENCE LEVEL · AGENCY EQUIVALENT · INSTRUCTOR TIER · — NOT OFFERED

Figure 1 - Cross-agency equivalency table.

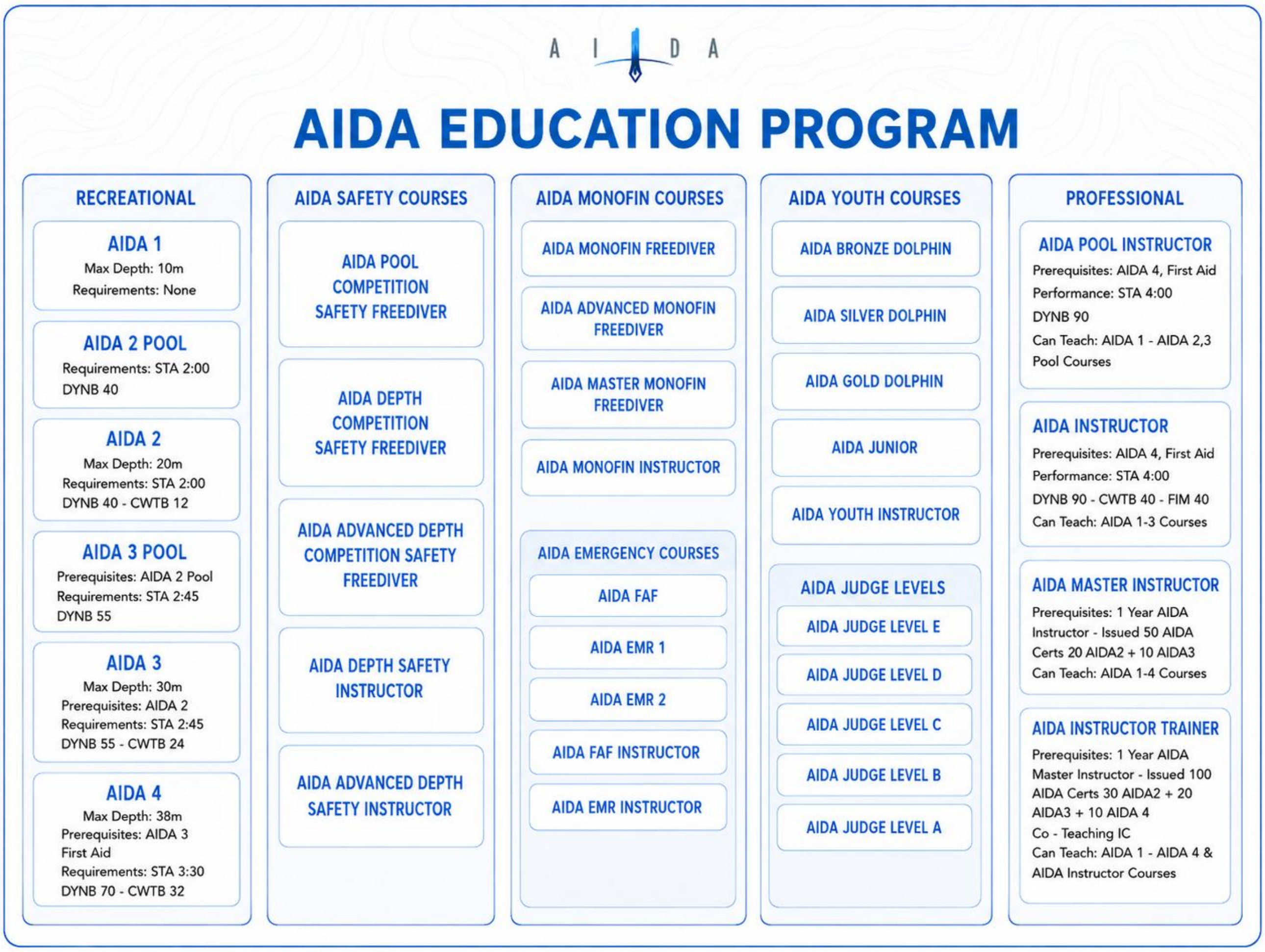


Figure 2 - AIDA Education Program

CHAPTER 2

2 PHYSIOLOGY

Most people can hold their breath for no more than 60–80 seconds, even under optimal conditions. Yet during your AIDA2 course, you have already gone well beyond two minutes.

What may seem surprising is, in fact, a natural expression of human physiology. By understanding how your body responds to breath-hold diving, you will be able to improve both your performance and your safety. This chapter will guide you through these fundamental mechanisms.

2.1 Blood composition

Approximately 8% of the body weight of an adult person is made up of blood. This results in an average of 4-5 liters for females and 5-6 liters for males, depending on body size. Blood has several functions in the human body:

- Transportation of gases, nutrients, waste products, hormones and body heat
- Protection from inflammation by providing leukocytes (white blood cells), antibodies and platelets
- Regulation of blood acidity (pH) by interacting with acids and bases, and water balance by transferring water to and from tissues in the body.

The transportation function of blood includes Oxygen (O_2) and Carbon Dioxide (CO_2), which are exchanged between the lungs and the cells in the body.

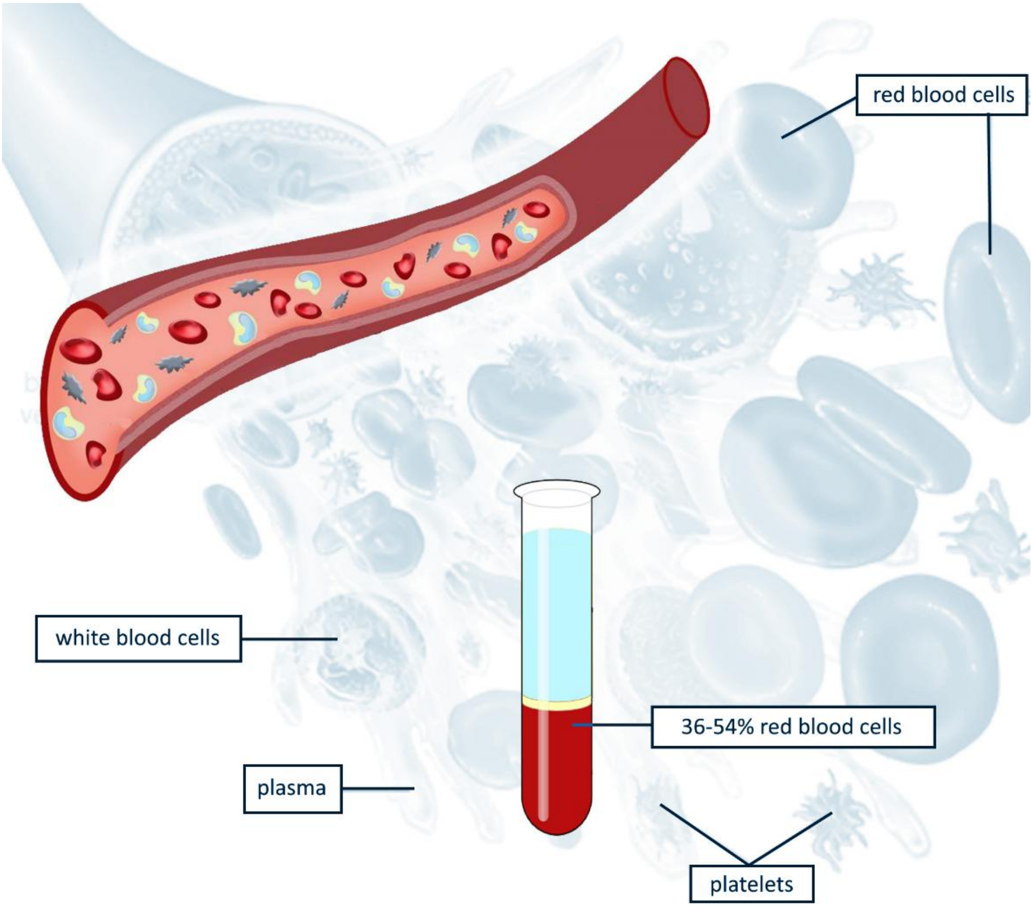


Figure 3 - Blood composition

Composition

Blood is a mixture of plasma (liquid part), red blood cells (RBC, or *erythrocytes*), white blood cells (WBC, or *leukocytes*) and platelets. The red blood cells contain an iron-rich protein called hemoglobin, which gives RBCs their red color. Hemoglobin carries most of the Oxygen transported by the blood.

Oxygenated: red

Oxygenated blood is bright red in color. This is the case in every healthy person, where the Oxygen saturation is 96-99% at any given time while breathing. You can test this with a simple *oximeter*, a device you stick to a finger to measure the oxygenation of the blood. The oximeter analyses the color of light reflections from the skin as an indicator of your blood oxygenation. If the oxygenation level is lower than 96% while breathing, you are either exerting or sick. In both cases, you should not hold your breath or freedive.

Oxygen depleted: purple

Oxygen-depleted blood shifts the color towards purple. This allows determining the oxygenation level of blood by its color. A pulse oximeter does exactly that.

Cyanosis

Cyanosis is often also called “blue lips”. As the skin is thinnest on the lips, a change in blood color can easily be spotted there. Cyanosis does not indicate a dangerously low level of oxygen in the freediver, but shows the oxygen level has started to decrease. The level will be normalized within a few breaths and cyanosis will disappear. As a freediver, you cannot “feel” cyanosis, hence, you depend on your buddy to tell you if it appears. Cyanosis in recreational freediving can be seen as the “first warning sign”. It tells you that you are approaching your personal limits and should not push further recklessly.

Note that blue lips can also indicate that the freediver has a slightly lowered body temperature (***hypothermia***). In this case, the color change derives from a constriction of the blood vessels (vasoconstriction) in the lips and does not indicate inadequate oxygenation. Still, it is important to tell your buddy if you notice blue lips. In case your diving partner feels too cold, you will have to react by conducting some warming up exercises such as swimming for a while, taking a break in the sun or, if nothing helps, by aborting the dive session. You should not dive when you are feeling cold.

In case the cyanosis persists over an extended period of time despite warming up, a freediver should seek medical attention.

2.2 Principle of diffusion

The gas exchange between air and blood happens in the alveoli, the smallest unit of your lungs. Once the inhaled air has reached the alveoli, it is separated from the blood in the surrounding capillaries only by the alveolus and the capillary walls, both of which are just one cell thick (Figure 4). Due to their thin cell walls, gasses are able to travel through these membranes in both directions – from air to blood and vice versa - following the principle of ***diffusion***.

Definition

Diffusion is the natural tendency of a gas to move from an area of high concentration to an area of low concentration.

Gradient

The speed of gas diffusion depends on the steepness of the so-called ***diffusion gradient***, i.e. the difference in concentration between two areas. The greater the difference, the steeper the gradient, the faster diffusion takes place.

Oxygen & carbon dioxide

In the context of freediving, we are mainly looking at two components of the gas exchange in the alveoli: Oxygen (O_2) diffuses from the inhaled air in the alveoli into the alveolar blood and carbon dioxide (CO_2) diffuses from the alveolar blood into the air in the alveoli. You will remember from your

AIDA2 course that while oxygen is essential for producing energy and sustaining vital functions, carbon dioxide is the main responsible of urge to breath and other sensations that appear when we hold our breath.

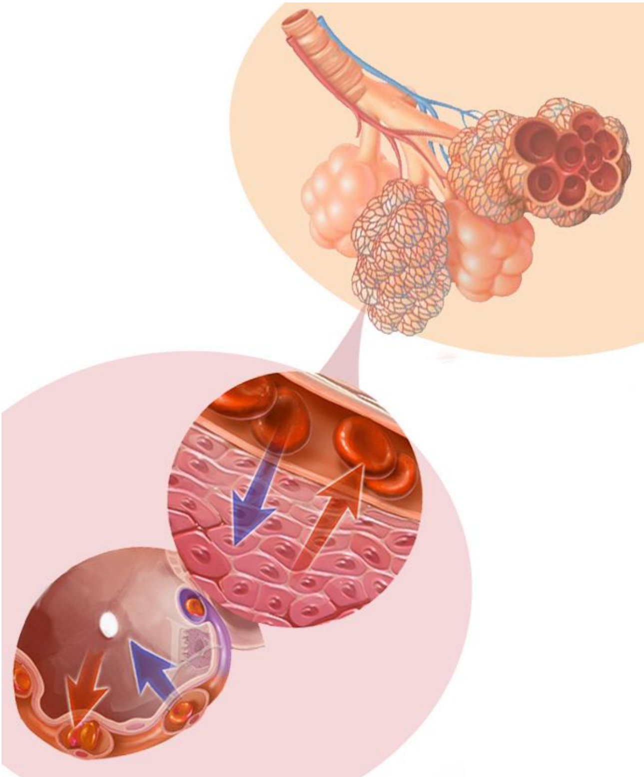


Figure 4 - Alveolus and capillary walls, gas exchange.

2.3 Cardiovascular system

The ***cardiovascular system*** (Figure 5) is the sum of all organs and tissues involved in the circulation of blood and lymph throughout the body. It serves as the transport system for oxygen—required for all cellular activities in the brain, organs, muscles, and other tissues—and carbon dioxide (CO_2), a waste product of cellular metabolism.

Arteries: Blood vessels carrying blood from the heart to the organs. Usually, this blood is saturated with oxygen (O_2-enriched) and low on carbon dioxide (low CO_2).

Veins: Blood vessels carrying blood towards the heart. Usually, the blood is de-saturated from oxygen (O_2 depleted) and saturated with carbon dioxide (CO_2 enriched).

Exceptions: The pulmonary *artery* is carrying blood low on O_2 from the heart to the lungs, while the pulmonary *vein* is carrying oxygenated blood from the lungs to the heart.

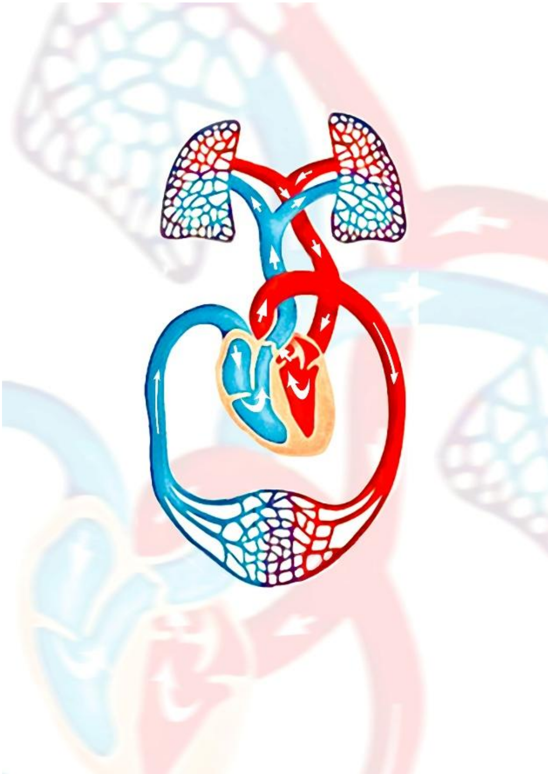


Figure 5 - The cardiovascular system.

Cardiovascular tour of O_2

We now have all the information needed to understand the whole journey of oxygen and carbon dioxide through our body. Imagine a few O_2 molecules hovering in front of you, and you are about to inhale them. This is where the journey starts.

1. Inhalation of air, including O_2 (see respiratory system in AIDA2)
2. O_2 diffuses into blood (gas exchange)
3. Most O_2 bonds with hemoglobin
4. Transport of O_2 from the lungs to the heart via pulmonary vein
5. Transport of O_2-enriched blood to any tissue (e.g. a muscle in the right hand) via systemic circulation
6. Tissue takes up O_2 and produces CO_2, which dissolves mostly in blood plasma
7. Transport of CO_2-enriched blood to the heart via systemic circulation
8. Transport of CO_2-enriched (and O_2-depleted) blood to the lungs via pulmonary artery
9. CO_2 diffuses into the air in the alveoli
10. Exhalation of CO_2-enriched air

2.4 Hyperventilation

You will remember from AIDA2 that hyperventilation (*over breathing*) means breathing in a way that leads to higher gas exchanges than needed to maintain a normal level of CO_2 in the blood, for your current activation state. This typically involves very deep or very rapid breathing (or a combination of both), which results in lowered CO_2 and blood acidity. Since the urge to breathe is primarily triggered by rising CO_2 levels in the blood, low CO_2 levels can suppress this signal and lead to hypoxic blackout, often with reduced or absent warning symptoms.

Reduced blood flow to the brain

Low CO_2 (hypocapnia) can decrease the blood flow to the brain, due to a constriction of blood vessels to the brain (cerebral vasoconstriction). This reduces the oxygen supply to the brain. Extreme states of cerebral vasoconstriction caused by hypocapnia can lead to a blackout while the freediver is still breathing at the surface.

Hyperventilation decreases breath-hold capability

Many of the oxygen-conserving mechanisms described in Chapter 3 (*mammalian dive response*, or MDR) are triggered or supported by rising carbon dioxide levels in the blood during apnea. Hypocapnia inhibits the MDR and thus the body will not conserve energy (oxygen) to the same extent as it would during a breath hold that has started with a normal level of CO_2. After hyperventilation, a hypoxic state is thus generally reached sooner than in a breath hold prepared by a relaxation exercise with the corresponding normal ventilation.

Bohr effect

Low CO_2 (*hypocapnia*) renders the blood more alkaline (i.e. less acid, or higher pH). This in turn makes the bond between hemoglobin and oxygen stronger. As a result, the bonded O_2 in the blood is less likely to be released to tissues. This is known as the **Bohr effect.**

Summing up:

Hyperventilation ⇒ ↓ CO_2 ⇒ ↑ pH ⇒ Cerebral vasoconstriction + Bohr effect ⇒
↓ Cerebral blood flow + ↓ Hindered O_2 release ⇒
No warning signs + Weaker MDR + Early hypoxia

Effect of hyperventilation on your breathold

In what follows, a simple model of how hyperventilation can affect your breathold is reported.

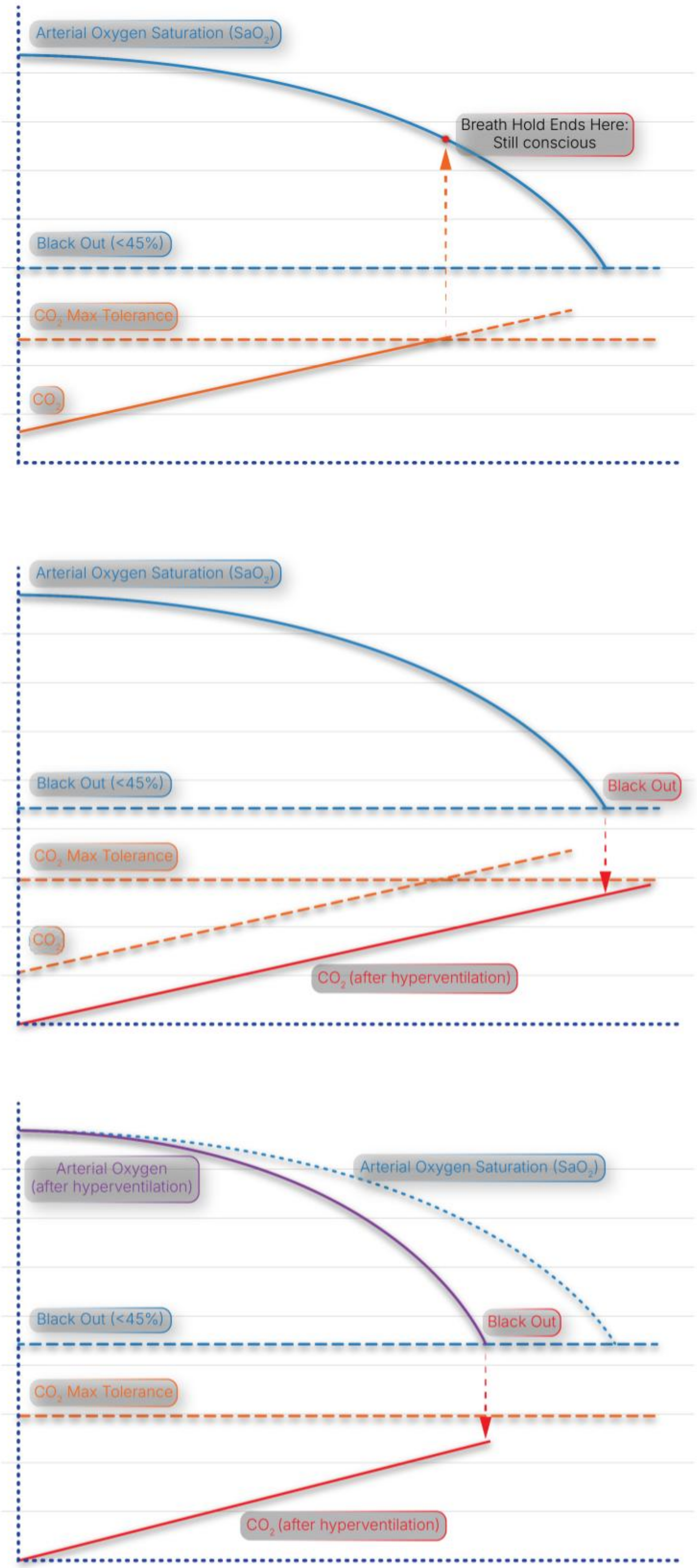


Figure 6 - Hyperventilation can lead to black out (Illustration concept by W. Trubridge)

During a breath hold, oxygen saturation in the blood decreases.

Starting from a normal saturation of about 96–99%, a freediver may black out when oxygen saturation falls to roughly 45%. In normal conditions, this is unlikely to happen because the urge to breathe caused by rising CO_2 usually becomes too strong much earlier. This gives the freediver enough warning to end the breath hold in time.

Hyperventilation does not significantly increase oxygen saturation in the blood. Instead, it lowers the level of CO_2. During the next breath hold, this means that the warning signs caused by rising CO_2 are delayed. In this situation, oxygen saturation may fall to blackout levels before CO_2 becomes uncomfortable enough to force the freediver to breathe. This is why hyperventilation can lead to blackouts.

Lower-than-normal CO2 levels also delay the energy-saving effects of the mammalian dive response. They also strengthen the bond between hemoglobin and oxygen, making it harder for oxygen to be released to the tissues. This is known as the Bohr effect.

As a result, the freediver uses up the available oxygen faster and may black out earlier.

Chapter 2 - Knowledge review

What is the function of blood in the human body?

What is cyanosis and why should you warn your buddy about it?

Define diffusion.

Define veins, arteries and the particular case of the lungs circulation

Hyperventilating does not change the level of Oxygen saturation in the blood, but it decreases its content of CO_2. True or False?

CHAPTER 3

3 THE MAMMALIAN DIVE RESPONSE

Until relatively recently, it was believed within the medical community that humans could not safely dive beyond moderate depths on a single breath. The prevailing assumption was that increasing ambient pressure would compress the lungs to a point where injury would be unavoidable. However, as freedivers gradually explored greater depths, they not only descended beyond what was once considered possible, but also consistently returned to the surface without signs of injury. This challenged existing physiological models and raised important questions within the scientific community.

At the same time, it remained unclear how professional breath-hold divers—such as the Japanese Ama, Greek sponge divers, and other traditional spearfishers around the world—were able to perform repeated, prolonged breath-holds while physically active. Even more puzzling was the observation that these same individuals could not necessarily replicate such performances on land, despite being at rest under minimal energy expenditure.

Part of this apparent paradox was clarified with the identification of what is now known as the ***mammalian dive response***. This physiological adaptation, well documented in aquatic mammals such as whales and dolphins, is also present in terrestrial mammals including humans (albeit in a less pronounced form).

3.1 Definition and macro effects

The academic debate surrounding the mammalian dive response (MDR) begins with its very name. It is sometimes referred to as the "diving reflex." In physiological terms, however, a reflex is defined as a single stimulus (such as the heat of a flame) leading to a specific response (such as withdrawing the hand). As will become clear in this chapter, this definition does not adequately describe the MDR. Rather than a *reflex*, the MDR is better understood as a physiological *response*: a combination of *multiple* stimuli that trigger *multiple* physiological reactions, or *adaptations*.

The study of the mammalian dive response falls within the broader field of hyperbaric science/medicine, a rapidly evolving discipline with new findings published regularly. This chapter provides an overview of the current knowledge relevant to freediving.

Series of triggers

The inputs (or triggers) to the MDR are the following:

- Apnea (rising CO_2)
- Water immersion
- Rising pressure (lung volume below residual volume – RV, see Chapter 4.1)
- Low temperatures

Series of adaptations

The outputs (or adaptations) of the MDR are listed below:

- Peripheral vasoconstriction
- Bradycardia
- Spleen effect
- Blood shift / haemocompensation
- Hypometabolism

These adaptations will be discussed in greater detail later in this chapter.

Multiple pathways and interactions

Triggers and adaptations should be understood as part of a complex, interactive system with multiple overlapping pathways. For example, elevated carbon dioxide levels (hypercapnia) can lead to peripheral vasoconstriction, promoting a redistribution of blood toward the thoracic cavity (centralization of blood volume, see *blood shift* in section 3.5). The autonomic nervous system responds with bradycardia (a reduction in heart rate, see section 3.3), helping to regulate cardiac output. Multiple pathways operate in parallel and interact dynamically, collectively contributing to the mammalian dive response.

Before discussing each adaptation in greater detail, let us consider two broad beneficial effects of the MDR.

Conserve oxygen

One of the main beneficial effects of the MDR is that it helps conserve oxygen throughout a dive. It supports the breath-hold by reducing heart rate (bradycardia) and, more generally, by slowing down metabolic activity, thereby lowering the body's overall oxygen consumption.

A second beneficial effect is that the MDR helps the body use the available oxygen more efficiently during a breath-hold. Blood flow to less vital muscles and organs is reduced, while oxygen delivery is prioritized for organs that are more sensitive to hypoxia, such as the brain and heart.

Prevention of lung barotrauma

One of the key components of the MDR is the *blood shift* (section 3.5): without this mechanism, mammals—including humans—would not be able to dive beyond approximately 25–35 meters without a significant risk of injury.

The following sections describe each adaptation that contributes to the MDR in greater detail.

3.2 Peripheral vasoconstriction

Peripheral *vasoconstriction* (the opposite of *vasodilation*) means that blood vessels in the extremities narrow, reducing blood flow to the outer parts of the body, especially the arms and legs, including the hands and feet.

Less oxygen available in the extremities

The constriction of peripheral blood vessels reduces blood flow to the extremities: as a consequence, less oxygen is delivered to tissues and muscles in these areas. These muscles can continue working for a limited time by relying increasingly on anaerobic metabolism, which occurs when their energy demand exceeds the oxygen supply available to them. They can continue functioning in this way until their local energy reserves are depleted. The underlying mechanisms are discussed in greater detail in AIDA4.

More oxygen available for the brain and vital organs

By reducing oxygen use in the peripheral muscles, the MDR helps preserve oxygenated blood for the thoracic region, where it supports the continued function of the brain and other vital organs during a breath-hold.

Lactic acid build up

The blood circulation not only delivers oxygen to muscles, it is also the mean of transport for any waste products away from the muscles, such as CO_2 or lactic acid.

Reduced blood flow due to peripheral vasoconstriction inhibits this cleansing process and leads to the buildup of lactic acid in the muscles of the legs and arms. This explains why your legs might start to feel “heavy” in an extended dive, or especially during a CO_2 table. While the surface intervals of your table are long enough to replenish your oxygen level, the breaks are not long enough to dispose of all excess lactic acid in your leg muscles before starting the next breath hold.

Tolerance training

Training lactate tolerance is an integral part of freediving training in general, and the goal of CO_2 tables in particular. This type of tolerance training is also familiar to athletes from many other disciplines, and can be developed, for example, with dry *interval training*. For a more detailed discussion of freediving training, please refer to AIDA4.

Surface intervals

Since peripheral vasoconstriction slows the clearance of lactate and other metabolic by-products from the working muscles, it is important to allow an adequate surface interval before a challenging breath-hold dive. Warm-up tables discussed in Chapter 9.1 recommend a minimum interval of four minutes before attempting a maximal performance. For general guidelines on calculating surface intervals between dives (that also takes into account aspects that relate to decompression illness), please refer to Chapter 8.5.

3.3 Bradycardia

In general, bradycardia refers to a slow resting heart rate, usually below 60 beats per minute (bpm) in adults. From a medical perspective it is classified as a type of cardiac arrhythmia, i.e. an irregular heart rhythm. Under normal resting conditions, however, it is not necessarily considered problematic unless the heart rate falls significantly, often below 50 bpm.

Freediving, in many respects, does not represent “normal resting conditions,” and heart rates well below this value may occur during breath-hold dives. In trained and healthy freedivers, such reductions in heart rate are generally considered a normal part of the dive response, rather than a negative event. On the contrary, because the heart is a muscle, reducing its activity helps lower energy demand and contributes to oxygen conservation during a breath-hold.

Slowing of the heartbeat

In untrained humans, bradycardia typically reduces heart rate by about 10–25%. In trained freedivers, a reduction of up to 50% from their normal resting heart rate may be observed.

Note that there is a correlation between peripheral vasoconstriction and bradycardia: The stronger the peripheral vasoconstriction, the steeper the drop of the heart rate.

Trigger: Facial immersion

Facial immersion is one of the triggers of bradycardia, especially when it is done in cold water. Some freedivers use brief facial immersion during preparation or warm-up to encourage this response before a breath-hold. Cold stimulation of areas such as the forehead and the region around the eyes is especially effective, and it has been used in scientific studies to induce or study diving bradycardia in a controlled setting by means of ice-water bags or cold packs.

3.4 Spleen effect

Spleen: reservoir for red blood cells

As blood circulates through the spleen, this organ also acts as a reservoir of red blood cells. These red blood cells can be stored and released when needed, for example in response to serious bleeding or in situations where an increased oxygen-carrying capacity may be beneficial.

Spleen contraction

Under certain circumstances, such as during apnea, the body may benefit from an increased oxygen-carrying capacity. The spleen can respond by contracting and releasing stored red blood cells into the bloodstream.

More oxygen carriers available

The resulting increase in red blood cell count allows the blood to carry more oxygen, thereby supporting the freediver's breath-hold capacity.

3.5 Blood shift / haemocompensation

In 1962, the Italian Enzo Maiorca became the first competitive freediver to dive beyond 50 meters during an official record. At the time, scientists considered such depths unsafe for humans, as increasing water pressure was expected to compress the chest and lungs beyond their physiological limits. It was not until 1974 that, by studying Maiorca's sporting rival Jacques Mayol on deep breath-hold dives, researchers began to understand the mechanism that allows mammals, including humans, to tolerate much greater depths: the blood shift, also known as haemocompensation.

Blood shifts toward the thoracic cavity

Due to peripheral vasoconstriction, an increased amount of blood is available in the torso to support the vital organs and the brain.

The blood vessels of alveoli increase in size

When a freediver dives below residual volume (RV, see Chapter 4.1), the lungs can continue to tolerate compression thanks to the blood shift. As blood is redistributed toward the thoracic cavity, the blood vessels around the alveoli fill with more blood and expand, helping compensate for the reduction in lung volume.

Compensation for volume loss due to pressure

The blood shift leads to an increased filling of the pulmonary blood vessels surrounding the alveoli, a process referred to as haemocompensation. As these vessels become more engorged, they help compensate for the loss of gas volume in the lungs. In this way, the alveoli can tolerate compression beyond what would otherwise be possible, because part of the space that would normally be occupied by air at the surface is progressively compensated for by blood.

A simplified analogy is to imagine an alveolus as an orange. The fruit flesh represents the air volume inside the alveolus, while the peel represents the blood vessels surrounding that air space. As the alveolus is taken deeper underwater, the "flesh" (air-filled part) becomes smaller and smaller as the air compresses, while the "peel" (pulmonary capillaries) swells to compensate for part of that lost volume. As a result, the overall size decreases far less than the air volume alone. At depth, your "orange" (the alveolus) contains less flesh and relatively more peel. Of course this is just a visual example: a real orange would not actually compress in this way, since it is made mostly of liquids and solids, but the analogy helps illustrate the principle.

Preventing negative pressure in the lungs

At depth, the air inside the alveoli undergoes significant compression. The blood shift helps compensate for the loss of gas volume by increasing the amount of blood within the thoracic cavity and pulmonary vessels. Since blood is far less compressible than air, it helps occupy part of the space lost by the compressed gas. This reduces mechanical stress on the lungs, because the lung tissues are not forced to collapse as much around the shrinking air spaces. It also helps limit the development of excessive negative pressure within the lungs: if the lungs are compressed significantly without the surrounding structures accommodating this compression, the pressure inside the alveolar air spaces may become lower than the pressure in the surrounding pulmonary blood vessels and tissues. This creates a pressure gradient across the alveolar walls, which can draw fluid—and in more severe cases blood—toward or into the alveoli. By reducing this pressure gradient, the blood shift helps protect the lungs from pressure-related injury at depth.

Blood shift reduces the risk of lung barotrauma

Diving below residual volume is not harmful in itself; however, the risk increases if the diver continues descending while the lungs are already under significant negative pressure, especially when the chest and diaphragm lack the flexibility to accommodate further compression. By helping compensate for the loss of gas volume, the blood shift delays the development of excessive negative pressure within the lungs and allows greater depths to be tolerated.

Nevertheless, dives below residual volume must be approached gradually, with small and controlled depth progressions and repeated exposure over time, allowing the body to adapt. The blood shift is not a “free pass” to progress recklessly, but a physiological response to a changing environment, and its effectiveness develops through time, training, and adaptation. Thoracic flexibility, which helps reduce residual volume (RV; see Chapter 4.1), works together with the blood shift to make deeper dives safer. Both factors require months or years to develop properly. Give yourself time, be patient and dive with absolute self-awareness:

Always be prepared to abort a dive at the first perception of discomfort in your chest.

Possible side effect: immersion diuresis and risk of dehydration

A side effect of the blood shift is that the increased central blood volume may be interpreted by the body as an excess of fluid. In response, the kidneys increase urine production to help reduce this perceived excess. In practical terms, this is why freedivers often feel the need to urinate during or after a dive session.

Because urine production may increase during immersion, fluids can be lost more rapidly, and dehydration may develop if they are not replaced.

It is therefore important to stay well hydrated before, during, and especially after freediving. Consider integrating with electrolyte when necessary.

3.6 Hypometabolism

Metabolism is the sum of all chemical processes that take place within the cells of a living organism. This rather abstract definition includes very concrete bodily functions, such as digestion. Many of these processes use oxygen to transform nutrients into energy and body heat.

Low metabolic rate

Hypometabolism refers to a state in which biochemical processes in the body slow down below their normal resting level. As part of the MDR, this contributes to a reduction in overall oxygen consumption, helping preserve oxygen for the brain and other vital organs during a breath-hold.

One practical example is the effect of freediving on digestion. During a dive, digestive activity may slow down significantly or temporarily stop, as the body prioritizes oxygen delivery to more essential functions. If food is still present in the stomach, this may cause discomfort and, in some cases, nausea or vomiting.

Possible side effect: Hypothermia

All biochemical reactions of the body emit heat and contribute to maintaining body temperature. If a freediver remains in a hypometabolic state for an extended period of time, heat production may decrease and the diver might feel cold more quickly. In more pronounced cases, this can contribute to a drop in body temperature (*hypothermia*), shivering and reduced ability to relax. This should not be ignored, as it can result in tension and increased oxygen consumption, which can reduce the diver's safety margins while increasing the risk of lung barotrauma.

Always wear appropriate thermal protection to avoid hypothermia.

Note that peripheral vasoconstriction can also play a role in perceiving more cold than normal during a dive.

3.7 Inducing the mammalian dive response

The MDR is a useful protective reflex. Learning how to safely maximize its effect it will result in more enjoyable and efficient dives. Remember, however, to also consider and minimize the potential side effects of this physiological response (dehydration, hypothermia, as discussed earlier).

MDR is naturally weak in humans

The mammalian dive response is strongly developed in marine mammals, much less pronounced in untrained humans. Even so, a splash of cold water on the face can be enough to trigger an immediate reduction in heart rate.

Stronger through training

For most non-freedivers, the mammalian dive response can be thought of as a mechanism that has remained largely unused. Beginning freediving is a bit like rediscovering this forgotten system: finding its controls, clearing away the dust, and learning how to activate it. With repetition, this old mechanism gradually comes back into gear and begins to run more smoothly. As with almost everything in freediving, this requires patience and consistent training. Over time, the mammalian dive response can become stronger, faster, and more effective.

Warm-up before maximum

Inducing the mammalian dive response is one of the main reasons to do warm-up dives (see Chapter 9.1) before maximum performance. Each warmup dive helps activating it, and smoothing out the sensations associated with it.

3.8 Summing up

Here is a short summary of the beneficial effects of MDR (compare them with the similar scheme reported for hyperventilation in Chapter 2.4):

↑ CO_2 ⇒ ↓ pH ⇒ Peripheral vasoconstriction + cerebral/pulmonary vasodilation + Bohr effect ⇒ ↓ O_2 Consumption + ↑ Cerebral blood flow + ↑ Facilitated O_2 release + ↑ Pulmonary protection

Chapter 3 - Knowledge review

What is the mammalian dive response (MDR)?

Why is the blood shift vital for deep freediving?

CHAPTER 4

4 LUNGS AT DEPTH

4.1 Lung measurements

Tidal Volume (TV)

Tidal volume is the amount of air inhaled and exhaled during relaxed breathing. In a resting adult, a single tidal breath is typically around 500 ml and occurs approximately 10–20 times per minute. Ideally, inhalation is driven primarily by the diaphragm, while exhalation is passive: air is not forced out of the lungs, but expelled by simply relaxing.

Inspiratory and Expiratory Reserve Volumes (IRV & ERV)

The inspiratory reserve volume (IRV) is additional amount of air that can be inhaled after a relaxed tidal inhalation. The expiratory reserve volume (ERV) is the maximum amount of air which can be exhaled after passive exhalation.

Vital Capacity (VC)

Vital capacity (VC) is the maximum amount of air that can be inhaled into the lungs after a full exhalation. In other words, vital capacity is the sum of inspiratory reserve volume, tidal volume, and expiratory reserve volume:

VC = IRV + TV + ERV

The vital capacity is thus the maximum volume of air we can access in one breath. Healthy adults have a vital capacity of 3-5 liters, depending on sex, body size, and age.

Note that vital capacity does not represent total lung capacity, as a portion of air remains in the lungs and cannot be voluntarily accessed; this is known as *residual volume* (described next). Training may increase vital capacity, partly by improving access to lower lung volumes and thoracic mobility, partly by determining a reduction of the functional residual volume.

Residual Volume (RV)

Residual volume (RV) is the amount of air remaining in your lungs after a forced exhalation. On average it is 25% of the total lung capacity (TLC, see below).

While other lung measurements are easy to acquire with a spirometer (a device to measure volumes of air inhaled or exhaled), the residual volume can only be determined indirectly, as it is not possible to “completely empty” the lungs.

In freediving, the residual volume is very important as it determines how deep you will still be able to equalize instinctively (see Chapter 6).

Functional Residual Capacity (FRC)

The functional residual capacity (FRC) is the volume of air remaining in our lungs after a relaxed exhalation. It can also be described as the sum of expiratory reserve volume and residual volume:

FRC = ERV + RV

A passive exhalation ends when the airways are open, the breathing muscles are relaxed, and airflow stops. This point can be perceived by producing a gentle sigh: relax completely, especially the abdomen, and exhale with a soft *“haaa…”* until no more air flows out. The volume of air remaining in the lungs at this point corresponds to the functional residual capacity (FRC).

In your future training with AIDA you will learn about a training method called “*FRC diving*” (see the ***AIDA4 Master Freediver*** course). It is sometimes incorrectly referred to as “empty-lung diving”. However, in FRC diving lungs are far from empty and are typically around 50% of the total lung capacity (TLC, see below).

Diving at residual volume (RV) is potentially dangerous and should only be practiced by highly trained athletes who fully understand the associated risks. For this reason, in the AIDA Education program, there are no dives performed on RV/empty lungs.

Total Lung Capacity (TLC)

The total lung capacity (TLC) is the total amount of air the lungs can hold:

TLC = VC + RV

Healthy adults typically have a total lung capacity of about 5-7 liters, depending on sex, body size, and age.

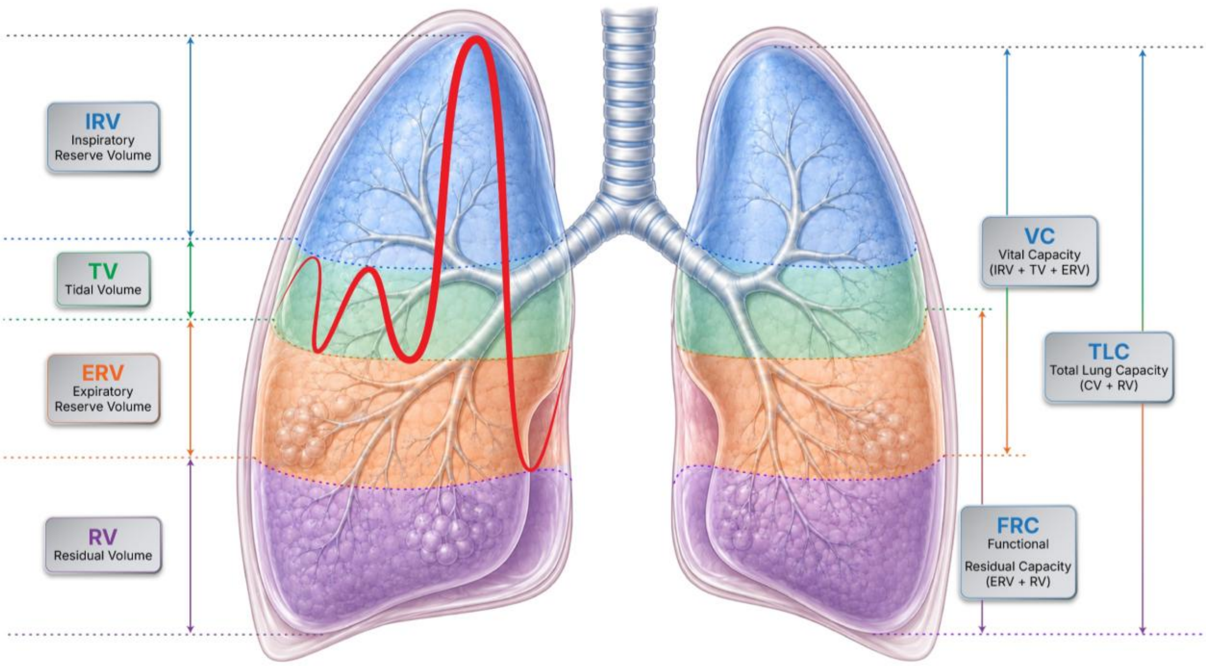


Figure 7 - Overview of Lung Measurements

In-depth: Spirometry and lung measurements

A basic spirometry test is not enough to directly measure the total amount of air your lungs can contain (TLC). When you perform a maximal exhalation during a simple spirometry, the value obtained is usually your vital capacity: the amount of air that can be moved in and out voluntarily. Even after a maximal exhalation, some air remains in the lungs: this is the residual volume. Residual volume, and therefore total lung capacity, cannot be directly measured with a basic spirometry alone. In a clinical setting, absolute lung volumes such as residual volume and total lung capacity can be measured or estimated using specific pulmonary function tests, such as body plethysmography, gas dilution or nitrogen washout.

Maximizing breathing volume

There is some confusion about whether total lung capacity (TLC) can be increased. Many methods can be found online: some aim to strengthen the breathing muscles, others focus on improving tolerance to high CO_2 or low O_2, and some have little practical value. However, very few of these approaches directly target the maximum volume of air that can be inhaled in a single breath, which relates to vital capacity (VC), not total lung capacity (TLC).

The most efficient way of increasing the vital capacity (VC) is to work on the following two aspects:

1. Proper one full breath technique as described in AIDA2: Train a slow two-stage inhalation to fill your lungs completely. Applying this technique correctly means accessing your maximum capability to inhale air into your lungs.

2. Reducing residual volume (RV) by stretching your respiratory muscles (mainly the diaphragm). Lowering your residual volume leads to an increase of your vital capacity VC and thus the amount of air that you have available per breath. This will be discussed in further detail later, as well as in the ***AIDA4 Master Freediver course***.

Relaxation phase: Tidal volume

The relaxation phase is the preparation period before a breath hold. The goal of this phase is to achieve a deep state of relaxation, both physically and mentally. As relaxation increases, breathing naturally becomes slower and more regular. The more relaxed you are, the less air needs to be moved in and out of your lungs.

The body automatically adjusts breathing to match the current level of activity, and there is generally no need to interfere with this process (see Chapter 2.4 and the drawbacks of hyperventilation). Breathing at tidal volume is something that should be allowed to occur naturally by relaxing into it.

4.2 Pressure and RV-Depth

As described above, your lungs reach residual volume (RV) after a maximum exhalation. This represents the smallest volume your lungs can normally reach at the surface.

Boyle's Law (see AIDA2) states that the volume of a gas is inversely proportional to the absolute pressure, often illustrated by an air-filled balloon compressed at depth. The structure of the lungs is more complex than a simple balloon, due to factors such as tissue elasticity, blood shift (see Chapter 3), and the mechanics of the chest wall; however, your lungs are still subject to Boyle's Law to some extent, and the balloon example remains a useful—albeit simplified—reference.

As depth increases, the volume of the gas decreases. At a certain point, lung volume will approach the residual volume (RV) measured at the surface, and may be compressed further due to increasing pressure.

Approaching RV

Approaching residual volume (RV) can be perceived as increasing pressure on the upper torso or chest. As a freediving proverb puts it, *"RV is close when the elephant steps on your chest."*

You should approach this depth with great care. Avoid jerky movements and control your descent speed, for example by using the diving rope if necessary. Give your body time to adapt and progress gradually over weeks and months.

The so-called "***failure depth***" refers to the depth at which lung compression approaches or exceeds the residual volume measured at the surface, and instinctive equalization becomes ineffective. It should not be understood as a fixed performance ceiling to be overcome by effort alone, but as a physiological and mechanical boundary related to the progressive reduction of usable lung air for equalization. In the following section, you will learn about potential injuries that may occur if this depth is reached too quickly and without proper preparation, and explore initial training concepts that will allow you to reach it safely.

For more advanced training and equalization techniques that allow freedivers to dive considerably deeper than the failure depth while staying well within safe limits and clear of potential adverse effects, please refer to the ***AIDA4 Master Freediver course.***

4.3 Lung barotrauma

Pressure-related Injury

Lung barotrauma (often referred to by freedivers as "lung squeeze") is a pressure-related injury of the lungs, most commonly associated with excessive lung compression at depth.

Body and mind need time to adapt to depth, and this process can take months, if not years, depending on the depth we are considering. Lung barotrauma typically occurs when a diver progresses too quickly beyond their current adaptation level. In other words, you go too deep, too early.

Before we delve deeper into this topic, it is important to be very clear about one thing:

Lung barotrauma is a serious injury that may have severe or even fatal consequences.
As such, it should never be taken lightly, and every effort should be made to prevent it.

Taking lung squeeze too lightly means acting irresponsibly. Every single incident of lung barotrauma needs to be properly treated with the support of a specialized medical doctor.

That being said, even experienced freedivers can suffer lung injury due to factors that go beyond adaptation to depth alone. Lung barotrauma can be triggered by a number of factors, such as insufficient relaxation due to stress or cold exposure. Both keep the muscles around the lungs from relaxing or stretching sufficiently to adapt to the rising environmental pressure. In any of these situations, the freediver should be aware enough to abort the dive before injury occurs, that is, before excessive negative pressure develops in the lungs during descent and stresses the delicate lung tissue.

In SCUBA diving, lung barotrauma is typically associated with breath-holding during ascent, where expanding gas in the lungs can exceed total lung capacity (TLC) and lead to overexpansion injury. While this mechanism may occur in specific cases in freediving, other mechanisms may also be involved. In freediving lung barotrauma can develop during descent due to excessive lung compression, or during ascent if prior lung stress or injury has reduced the effective lung volume or altered gas distribution. In both cases, the underlying issue is an imbalance between pressure and the lung's ability to adapt.

Fluid enters lungs

Damage to lung tissue can lead to fluid leaking into the airspaces of the lungs as a result of pressure-related stress. The presence of fluid in the alveoli impairs gas exchange and, in severe cases, may make it impossible.

Signs and symptoms

There are several symptoms that indicate a lung injury upon surfacing after a dive. You might feel tightness in the chest that does not disappear. The airways might be obstructed to a certain degree, which creates a wheezing sound while breathing.

Even after a few breaths at the surface, you may experience a persistent feeling of breathlessness. You may feel the urge to cough in an attempt to clear your airways, and in some cases may expel a pink, foamy fluid. You may also experience fatigue that does not quickly resolve. If you experience one or more of these symptoms, you may have sustained a lung injury and should seek medical evaluation.

Emergency procedure

If you experience one or more of the symptoms described above, it is important to immediately initiate the following emergency procedures:

- **Immediately stop diving**: do not perform any further dives, including buddying, and avoid any physically demanding activities such as pulling up the rope or transporting weights.

- **Avoid forceful coughing**, even if you feel a strong urge to do so. If you need to cough, do so gently and spit the expelled fluid into your palm. Check the fluid for traces of blood or pink foam. Breathe calmly, with slow and shallow breaths, even if this may be difficult due to fatigue.
- **Control your breathing and focus on relaxation.** Inform your buddy about any symptoms you are experiencing, and do not try to hide discomfort. Move slowly to help keep your heart rate low. Your buddy should assist you and take care of all necessary tasks, such as bringing you back to the boat or shore.
- **If available, breathe oxygen.** Fluid in the lungs interferes with gas exchange; breathing oxygen can help improve oxygenation and may reduce fatigue.
- **Seek medical assistance** after every incident in which you have experienced one or more of the symptoms described.

Stop diving for at least one week, seek medical help

It is essential to allow sufficient time for the lung tissue to heal completely. Diving should be stopped for at least one week, and possibly longer depending on the severity of the injury. Returning to diving too early may lead to relapse, chronic injury, or serious complications.

As it can be difficult to assess recovery on your own, it is important to obtain medical clearance from a qualified physician before resuming diving.

4.4 Avoiding lung squeeze

Lung barotrauma must be strictly avoided. Too often, lung injuries are downplayed by freedivers as a minor setback on the way to greater depths. Some have even compared lung barotrauma to a muscle strain in other sports—this is misleading. Repeated lung injuries can lead to chronic conditions, and returning to freediving before full recovery may result in serious complications or, in extreme cases, be fatal.

Self-awareness is key

At every level, freediving should be about self-awareness rather than numbers. Some of the greatest freedivers of all time, with multiple world records and world championship titles, have never experienced a lung squeeze (and some have never even blacked out). This is largely due to their deep awareness and respect for their physical and psychological limits, as well as their consistent, gradual training over extended periods of time.

Dive relaxed or do not dive

The safest way to approach freediving is through relaxation: from your first freediving class you have learned how to consciously calm your body and mind using relaxation techniques. At times, relaxation comes easily, while on other days it may take longer to settle into a calm state. To reduce the risk of injury, always allow yourself the time you need to reach that state.

Stop diving if you feel stressed or cold

Stress is the opposite of relaxation: it creates tension in both mind and body, and increases breathing and heart rate. In a pool dive, this will typically reduce your dive time or distance, as energy reserves are consumed more quickly. Depth diving, however, is different. Both body and mind need to adapt to the sensation of increasing pressure. If you resist this sensation—consciously or unconsciously—you increase the risk of injury. Stress reduces self-awareness and can lead to dangerous resistance. The solution is simple: be honest with yourself and do not dive if you feel stressed in any way. If you do not feel confident about a dive, skip it. Inform your buddy, return to your relaxation routine, and allow yourself the time you need.

If you become cold, your body will start shivering to generate heat. Shivering increases muscular activity and tension, which interferes with relaxation. As a result, if shivering begins, you should stop diving and exit the water to warm up.

Stretching of intercostal muscles

The muscles around the thorax, and especially those involved in breathing, can be trained like any other muscle in the body. Training should include both strengthening and improving flexibility; neither should be neglected. Strengthening the breathing muscles helps sustain longer dives without fatigue, while improved flexibility allows the thoracic structures to accommodate greater compression and reach greater depths.

By reading about freediving or talking to more experienced freedivers you may encounter a technique called "packing." At this stage, it is not necessary to explore it in detail. Its applications, as well as the associated risks, are covered in the ***AIDA4 Master Freediver course***.

It is mentioned here only because some freedivers combine it with full-lung stretches in an attempt to increase their vital capacity (VC). However, it has been shown that this is a potentially harmful practice associated with long-term damage to lung tissue and should thus be avoided.

Packing is not necessary for deep freediving and may be harmful when combined with stretching. However, you may still encounter it in various sources, including books, online material, and coaching practices. Freediving encompasses a range of approaches, and as a relatively young and evolving discipline, knowledge continues to develop. It is however important to rely on well-established, evidence-informed practices, and to prioritize safety in your training.

Diaphragm stretching: Uddiyana bandha

You can train the flexibility of your breathing muscles at the end of the exhalation and thus reduce the residual volume (RV) of your lungs with a yogic practice called *uddiyana bandha* (Figure 8).

You can learn this technique from your AIDA Instructor or your yoga teacher in more detail. Below you can find a short summary of the technique. In broad strokes, uddiyana bandha is done in these steps:

1. Warm up your breathing muscles using your preferred method (e.g. light gymnastics, sun salutations, or breathing exercises such as *bhastrika* or full yogic breathing).
2. Stand with your feet slightly wider than shoulder-width apart, lean forward, and rest your hands on your thighs or knees.
3. Exhale fully and gently close your airways.
4. Draw your navel inward toward the spine and then upward toward the thorax.
5. The chest expands while the diaphragm is drawn upward.
6. Hold briefly.
7. Relax all muscles.
8. Release the airway closure and allow air to flow in gently, resuming normal breathing.
9. Repeat from step 3.

As a variation, you can perform this sequence seated instead of standing.

Apply the correct turn at depth

In your AIDA2 course you learned how to correctly stop your descent and start your ascent. This is of even greater importance when you dive around or beyond your residual volume. Execute your turn at depth slowly and gracefully. Avoid aggressive or jerky actions in general, and do not perform “opening” movements like the so-called “parachute turn”.

Slow adaptation and inducing blood shift

Every great journey starts with a first step, followed by another, and then another. Progress in freediving should be gradual: increase your depth in small increments beyond your previous limits. Repeat dives at an achievable depth to allow your body and mind to adapt before setting a new goal. This goal should be challenging, but not too far from what you have already accomplished. Give yourself time, enjoy the process, and stay safe.

Start your freedive sessions with a series of warm-up dives to allow your body and mind to adapt and “switch into freedive mode”. Chapter 9.1 elaborates in detail how you can design your personal warm-up ritual.

Giving yourself time during warm-up allows your body to induce the blood shift, which is a part of the mammalian dive response (see Chapter 3).

Note: To ensure gradual progression, it is recommended that you never attempt dives more than 3 meters deeper than your current personal best.

Figure 8 - Uddiyana Bandha to stretch the diaphragm.

Chapter 4 - Knowledge review

What is the residual volume?

What is the most efficient ways of increasing the vital capacity?

What is the failure depth?

There are several symptoms that indicate a lung injury upon surfacing after a dive. Name at least two of them.

Give four or more good advices that help to avoid lung squeeze.

CHAPTER 5

5 BUOYANCY

Buoyancy control is a fundamental skill in freediving, both for safety and energy efficiency. Being too heavy is clearly dangerous, as you may sink from the surface or overexert yourself when returning from a dive. However, the opposite can also be true: being too light does not necessarily mean being safe. Excessive positive buoyancy may force you to work harder during the descent, leading to unnecessary effort and fatigue.

Buoyancy control must therefore be adapted to each specific diver, depending on the setting, discipline, and target depth.

This aspect was already relevant in AIDA2, but it was largely managed by your instructor. In AIDA3, freedivers are expected to take responsibility for their own buoyancy control and learn to use it to their advantage, for example by introducing and properly managing the free-fall phase in deep dives.

5.1 Archimedes Principle

Definition

Let us start by recalling the formulation of this famous principle:

" An object partially or fully immersed in a fluid experiences an upward buoyant force equal to the weight of the displaced fluid."

As a result of the buoyancy force, when you swim or dive, you experience an apparent loss of weight equal to the weight of the water displaced by the immersed volume of your body.

To be more precise, when you are in the water, your body is subject to two opposing forces. The downward force is simply your weight, while the upward force is the buoyant force described by Archimedes' principle. The interaction between these two forces determines whether you sink, float, or remain suspended in the water. This has several interesting consequences for freediving, which will be described in what follows.

5.2 Neutral buoyancy

Remain at same depth effortlessly

Neutral buoyancy (NB) is established when weight and buoyancy force cancel out:

Your weight = Buoyant force

As a freediver, you have reached neutral buoyancy when you can maintain your depth without effort—you are neither floating up nor sinking down. Finding the exact depth where this happens requires patience: here is how to do it.

- Descend using free immersion to the depth at which you estimate you will be neutrally buoyant.
- At that point, form an "OK" sign with your thumb and index finger around the rope. Let go of the rope with your other hand and allow your whole body to relax.
- Do not try to hold your body still; instead, let it move freely, allowing it to drift, twist, or rotate naturally.
- In this relaxed state, slowly count down from ten to one in your mind.
- If you remain at the same depth throughout the entire countdown, you have found your neutral buoyancy.
- If you start moving upwards during the countdown, you are too shallow and should pull yourself slightly deeper.
- If you sink, you are too deep and should move slightly toward the surface along the line.
- Adjust your position by approximately one arm's length and repeat the countdown.
- Continue this process until you either need to surface or successfully identify your neutral buoyancy.

In practice, it may take several dives to determine your neutral buoyancy accurately. You can use your warm-up dives at the beginning of each open water session to practice this.

Set neutral buoyancy according to the dive

You should adjust your neutral buoyancy according to the target depth of your dive session by using more or less weight. The goal is to find a good balance between ease of descent and ease of ascent, while minimizing overall effort during your planned dives. Setting your neutral buoyancy too shallow (e.g. above -10 m) may increase the effort required during ascent, while setting it too deep (e.g. beyond -20 m) will make the descent more demanding. As your target depth increases, your neutral buoyancy should be set deeper accordingly.

As a rule of thumb, neutral buoyancy can be set at approximately one-third of your target depth. This means that neutral buoyancy becomes particularly relevant for dives deeper than -30 m. For shallower dives, it is generally kept at a safe minimum depth of around -10 m.

Shallow NB should NOT replace lack of technique

It is important to note that setting your neutral buoyancy too shallow is not a substitute for proper freediving technique. If you have difficulty descending from the surface at the beginning of your dives, it is essential to improve your duck dive.

Overweighting to compensate for technical shortcomings is dangerous and should be avoided.

A simple safety check is to confirm that, at the surface, you remain buoyant and do not start sinking after a full exhalation. Passing this check does **not** necessarily mean that your weighting is correct (use the full procedure explained above to verify that), but it does indicate that you are not severely overweighted, which would be dangerous.

5.3 Freefall

In the AIDA2 Freediver Course, you were diving above your point of neutral buoyancy or only slightly below it. It is now time to leave beginner freediving behind. As you go considerably deeper than your neutral buoyancy, the air in your lungs and the small gas bubbles in the neoprene of your wetsuit are compressed. As a result, your overall volume decreases, which reduces the buoyant force acting on your body. With less buoyancy, the balance shifts in favor of your weight, and you begin to sink more easily:

Your weight > Buoyancy force

When this happens, gradually, you become negatively buoyant, and you feel like being “pulled” effortlessly to depth - you start to “freefall”.

On descent past (deeper than) NB

On your descent, you build up some speed by finning or pulling yourself down along the line. As you get close to your depth of neutral buoyanc you will notice that you are able to maintain that same speed with decreasing effort. A few more kicks (or pulls) get you almost effortlessly past neutral buoyancy and soon you will be able to keep the same speed without any further propulsion. Your free fall has begun and will take you to your target depth.

Streamlining & relaxation

The freefall is essentially a passive phase of the dive, similar to a static breath-hold, during which the diver focuses on streamlining and equalization. During the freefall, aim to maintain a streamlined, vertical body position, with your head aligned with your body axis. This can be achieved with minimal effort while keeping your focus on complete relaxation.

At times, freefall may feel slow, with the rope in front of you seemingly motionless. Learning to exploit this phase of the dive can require patience and confidence. If you get distracted in this phase of the dive, try to return to your relaxation routine and maintain focus on proper equalization.

Keep your head aligned with your body axis throughout the freefall. Looking down not only increases drag, but also alters your body position, creating a "banana shape." This gradually shifts your body away from the vertical line and toward a more horizontal position. Eventually, you may end up in a parachute-like posture, with your torso facing downward. Just as a skydiver slows their descent by adopting this position in air, it will also slow down your freefall in water.

Workshop: Freefall steering *(by J. Sunnex and W. Trubridge)*

During freefall, the body can deviate from a perfectly vertical position in two main planes: the sagittal plane and the frontal (or coronal) plane.

1) Sagittal deviations: *The sagittal plane divides the body into left and right halves. Deviations in this plane occur when you tip forward toward the line or lean backward away from it. These are often caused by improper weight distribution (too much weight on the front or back of the body) or by tension in the legs.*

The upper body is generally more buoyant than the lower body. When diving upside down, this can create instability—similar to an arrow with heavy feathers. Positioning weight closer to the head (e.g. around the neck) helps stabilize the freefall.

If you tip forward, you may start brushing against the line. If you lean back, you will drift away *from it, and your lanyard may become taut, creating drag. These deviations can be corrected by gently adjusting the position of the head and neck. Avoid excessive movement: the head should remain aligned with the body, and your gaze should stay on the rope.*

2) Frontal (coronal) deviations: *The frontal plane divides the body into front and back halves. Deviations in this plane occur when the body drifts to one side. This is typically caused by uneven weighting (e.g. more weight on one side of the belt) or asymmetrical body tension.*

If you consistently drift to one side, identify and correct the underlying cause rather than compensating with movement. You can recognize this deviation when the rope shifts toward one side of your visual field. It is important to correct it early, before it becomes significant and disrupts your streamline.

In CNF (constant weight no fins) and FIM (free immersion), frontal deviations can be corrected using the legs, similar to a rudder. Slightly externally rotating one foot increases drag on that side, causing the body to turn in that direction (e.g. rotate the right foot to move right).

In CWT (constant weight with fins), frontal deviations are less common, as fins help stabilize the body. With bi-fins, small corrections can still be made by creating slight asymmetry in drag. With a monofin, subtly extending one leg more than the other will cause the body to move toward the opposite side.

Ascend against negative buoyancy

Upon reaching your target depth, you will grab the rope, make your turn, and begin your ascent. At first, you may notice that gaining speed requires effort, as you are swimming against negative buoyancy. Focus on maintaining efficient fin kicks or, in free immersion, steady and controlled arm pulls, while keeping a streamlined body position.

As you ascend and approach your neutral buoyancy depth, you will experience the reverse effect of the descent: maintaining speed requires progressively less effort. Once you pass this point, only a few more movements are needed before the expanding air in your lungs provides enough buoyancy to lift you effortlessly toward the surface. At this stage, you can stop moving and allow yourself to float up.

Save oxygen

Applying only the amount of effort needed to maintain your speed is a key principle in freediving. At the beginning of the dive, you must swim against positive buoyancy. As you descend, the required effort gradually decreases until you enter the freefall phase. The transition from active swimming to freefall is not abrupt, but smooth and progressive. Once in freefall, you save a significant amount of energy—and therefore oxygen.

This can be illustrated with a simple example: a CWTB dive to -30 m may appear equivalent to a horizontal swim of 60 m. However, the actual effort depends on how the dive is distributed. Assuming neutral buoyancy is set at -10 m:

- Descent 0-10m strong kicks
- Descent 10-20m gradually relaxed kicks
- Descent 20-30m free fall
- Ascent 30-20m strong kicks
- Ascent 20-5m gradually relaxed kicks
- Ascent 5-0m ascent by buoyancy (meters are approximate)

In this example, the effective distance along which you are kicking hard is no more than 20 meters, another 25m is gradually more relaxed and a total of 15m is actually effortless. This represents the dynamic of a well-executed dive.

Self-awareness: Stop descent immediately in case of discomfort

As always in freediving, it is important to dive guided by self-awareness rather than by numbers. If you feel any discomfort during your freefall, immediately stop your descent, take hold of the line, relax, and begin your ascent in a controlled manner.

How to train free fall

When training freefall, you are working toward two main goals: identifying the optimal starting point of the freefall and developing effective streamlining.

Chapter 5.2 explained how to find your neutral buoyancy. The point from which freefall begins is deeper than that, and you will need to determine it individually. The following example refers to CWTB, but the same approach can be applied to FIM:

1. Count your kicks until you reach neutral buoyancy.
2. Continue kicking for approximately four more kicks (counting one leg only to stay consistent, e.g. “right… right… right… right… stop”).
3. Stop kicking, maintain a streamlined position, and allow yourself to enter freefall.
4. Observe your speed.

During freefall, your descent speed should remain approximately the same as it was while kicking. If your speed drops significantly, you likely stopped kicking too early (i.e. at too shallow a depth).

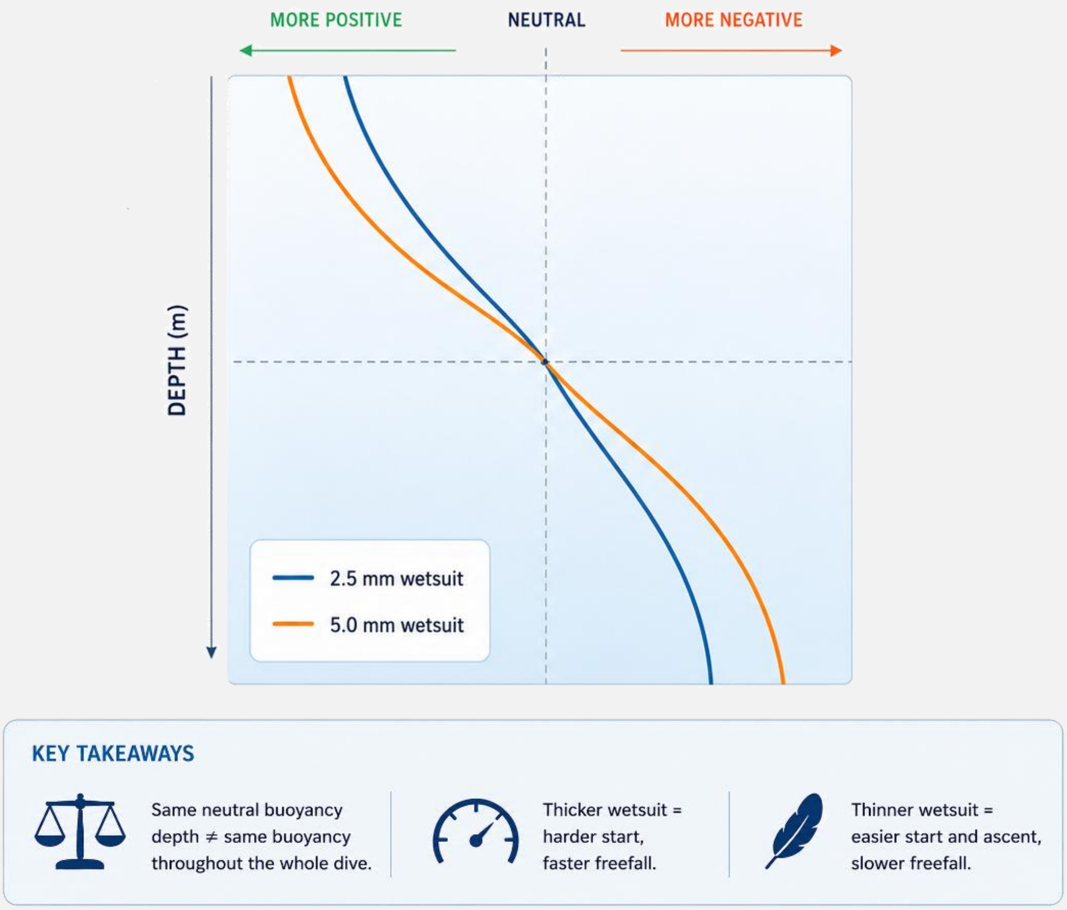
On your next dive, add a couple of kicks and reassess. Finding the right balance between propulsion and freefall requires sensitivity and experimentation, particularly in how you modulate the strength of your kicks. In practice, it is rarely a simple switch between kicking and not kicking, but rather a gradual reduction in effort. With repetition, you will develop a precise sense of your speed and learn how much energy is needed to maintain it.

Once in freefall, streamlining becomes essential. Streamlined does not mean rigid, but relaxed and aligned, maintaining a straight vertical posture. Excessive tension wastes energy without providing meaningful benefit. Stay relaxed, keep your head aligned with your body axis, and either close your eyes or maintain a soft focus on the rope. This allows your body to remain stable and aligned, supporting a smooth and efficient descent.

Figure 9 - Free immersion.

In-depth: Wetsuit thickness and buoyancy variation *(concept and data by Jun Matsuno)*

Two divers may be neutrally buoyant at the same depth and still experience the dive very differently. The same can happen to one diver when changing to a different wetsuit thickness and adjusting the weight to keep the same neutral buoyancy depth.



A thicker wetsuit contains more compressible gas in the neoprene and therefore requires more weight to reach the same neutral buoyancy depth. Near the surface, before the neoprene is compressed, this makes the diver more positively buoyant and the start of the descent more demanding. At depth, after compression, the same diver becomes more negatively buoyant, which may result in a faster freefall and a more demanding beginning of the ascent.

A thinner wetsuit creates a smaller buoyancy variation throughout the dive. The start of the descent and the first meters of ascent may feel easier, while the freefall may be slower.

Correct weighting is therefore not only about where the diver becomes neutral, but also about how buoyancy changes throughout the whole dive.

Chapter 5 - Knowledge review

Being "too heavy" is obviously dangerous but being "too light" does not always means to be safe in freediving. Please comment.

Explain and comment on this: "Setting your neutral buoyancy shallower does not replace good technique."

If you fall off-balance during freefall, what are your main means to correct that?

CHAPTER 6

6 EQUALIZATION

In the AIDA2 Course, you learned the basics of equalizing your ears and your mask. This chapter explains in further detail what happens during an equalization maneuver and concludes with an introduction to the recommended equalization technique: the Frenzel maneuver.

6.1 Elements of the ear

Outer ear

The outer ear (Figure 10), or outer auditory canal, is the space between the eardrum and the outside world. During freediving it should be filled completely with water, as any remaining air in your outer ear could make equalization harder, or even result in an injury.

Depending on the shape of your ear and how tight your hood is, the ear might automatically flood as soon as you submerge. This is not always the case however: in some cases a hood can prevent air from escaping and your outer ears will not fill up with water.

When freediving with a hood, it is thus important to lift it slightly off your face at your temples to allow both your outer ears to fill up with water prior to every dive. Alternatively, you can poke small holes in your hood where your outer ears are in order to allow air to escape automatically when diving.

Ear drum

The eardrum (Figure 10) separates the outer ear from the middle ear. It is slightly flexible and thus very sensitive to register changes in environmental pressure.

As described in AIDA2, there is a difference between the sensation of pressure-change and pain. Feeling pressure is essential for an efficient equalization technique, while experiencing pain while diving is always an alarm signal upon which you should stop your descent immediately.

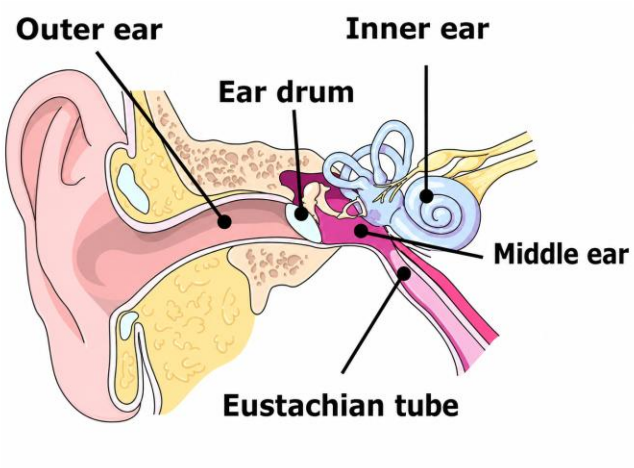


Figure 10 - Anatomy of the ear.

Middle ear: Filled with air

The middle ear (Figure 10) is the air-filled space between the eardrum and the inner ear. This is the part of the ear we must equalize during diving.

Eustachian tubes

The Eustachian tube (Figure 10) connects the middle ear with the nasopharynx. The connection with the nasal cavity is the reason why – in normal physiological conditions – sinuses are automatically equalized when we equalize our ears.

Muscles around Eustachian tubes

Some parts of the Eustachian tubes are surrounded by muscles which, in their default state, keep the tubes closed. These muscles can contract and open the Eustachian tube orifice in certain situations, for example during swallowing.

You can verify this yourself. In a quiet environment, swallow some saliva while listening closely: you should hear a slight clicking sound in both ears, indicating that the tubes are opening.

Swallowing can, in fact, serve as a basic equalization technique. However, it is relatively slow and effective only for small pressure changes, making it suboptimal for freediving.

The more relaxed the muscles around your Eustachian tubes are, the smoother your equalization technique works. “Hands-free equalization” means that you can intentionally contract the muscles around the Eustachian tubes.

Inner ear

The organ responsible for hearing is the inner ear, or cochlea (Figure 10). It is located deep within the skull, approximately behind the eyes. Being fluid-filled, it does not require equalization in response to changes in external pressure.

Figure 11 - Overview of the sinuses.

6.2 Anatomy of sinuses

Hollow spaces

Sinuses are a connected system of several hollow cavities in the skull. The largest are roughly 2.5 centimeters in diameter, while others are much smaller.

Air filled

Sinuses are hollow, air-filled cavities, which makes them compressible and therefore subject to pressure changes. As anticipated, under normal physiological conditions they are automatically equalized when the ears are balanced. While the general purpose of the sinuses is not exactly clear, they certainly reduce the weight of the skull and add resonance to the human voice.

Mucus

Sinuses are lined with a soft, pink tissue called mucosa, covered by a thin layer of mucus. The mucus helps to humidify the inhaled air and traps irritants before they can enter further into the breathing system.

Importance of proper ventilation

Each sinus has a narrow spot called *transition space* or *ostium*, through which the sinus is constantly drained from old mucus, mostly towards the nose. Production of fresh mucus allows old mucus to be expelled together with the trapped irritants.

Proper ventilation of the sinuses is thus vital for a constant replacement of old mucus with freshly produced mucus.

Techniques for proper ventilation

Apart from blowing your nose a few times per day, the elimination of old mucus can be greatly supported by certain yogic techniques. The cleansing exercises "*kapalabhati*" and "*neti*" are probably the most beneficial ones and can be conducted on a daily basis. Many AIDA Instructors will teach these techniques in special workshops complementary to the AIDA Courses.

Although relatively common, flushing the sinuses with seawater for cleansing purposes is not recommended. While it may occasionally provide short-term relief, it carries a significant risk of infection. Seawater is not the clean saline solution one might assume; it may contain pollutants, microorganisms, and a wide range of pathogens. Intentionally introducing such substances into the body should therefore be avoided.

That said, incidental exposure does occur. Surfers, for example, are often familiar with seawater draining from the nose hours after their last session. As always, it is the dose that makes the difference: while small amounts are generally not problematic, deliberate ingestion or infusion should be avoided whenever possible.

6.3 Improving equalization technique

AIDA2: Introduction to equalization technique

During a descent in water pressure increases, compressing the air in the middle ear. As a result, the eardrum is pushed inwards, reducing the air space in the middle ear. To equalize this pressure you must push air into the middle ear through the Eustachian tubes. See your AIDA2 manual for full description of equalization.

Avoid Valsalva maneuver for freediving beyond beginner level

The Valsalva maneuver described in AIDA2 is a perfectly valid equalization technique for SCUBA or even for shallow dives at beginner level, but it will not work at greater depths (past 8-10m in a head down dive, normally). The reason it becomes progressively less efficient with depth is that it relies on generating pressure from the lungs and transmitting it to the upper airways while lung volume is decreasing and ambient pressure is increasing: our respiratory muscles are not designed for that.

Starting with the AIDA3 Course (and beyond) you should refrain from using Valsalva and shift to the more efficient Frenzel technique.

Learn and apply Frenzel maneuver

To develop (or become aware of) the Frenzel maneuver, try the following steps:

1. Breathe calmly through your nose
2. Close your throat (glottis), as you would in order to hold your breath
3. Pinch your nose with your fingers
4. Pronounce a “T” or a “K”, gently pushing your tongue against this locking position, gradually increasing the pressure.

If these steps result in successful equalization, you are most likely applying the basic principles of the Frenzel technique (also known as Marcante–Odaglia). However, if you notice tension in your abdomen during the process, you may be performing a Valsalva manoeuvre instead, or a combination of the two.

If you are still unsure, ask your buddy to place a hand on your abdomen while you equalize. If any movement is detected, even slight, you are not yet applying the Frenzel technique correctly.

Your AIDA Instructor can help you master the Frenzel maneuver.

Benefits of the Frenzel technique

In comparison with Valsalva, the Frenzel technique is much more relaxing and effective, and can be used considerably deeper than 8-10m. In fact, it will allow you to gradually reach the depth where your lungs approach your residual volume, provided that your technique and relaxation support your dive. To explore beyond this depth, you will need more refined equalization tools, which will be explained in the ***AIDA4 Master Freediver course***.

Equalization stretching and Eustachian tube exercises

The muscles around the Eustachian tubes are connected with the jaw and (indirectly) with the neck. Gentle stretches of your neck and jaw muscles thus facilitate equalization. Below you can find some tips and tricks for practicing stretching to support your equalization.

In-depth: stretching exercises for better equalization

1. ***Stretch no. 1:*** *While standing or sitting with a straight spine, allow your right ear to drop down to your right shoulder. Stay there, feel the tension on the left side of your neck, and let go of any tension you may notice. When you sense no more tension that you can let go of, raise your right arm, reach over your head and place your right hand on your left ear. Do not pull on your head, just allow the extra weight of your arm to pull your head down a bit further. Stay in this position for 5-7 relaxed breaths. Then release the hand and let go of the ear first and slowly raise your head back to the center. Repeat on the other side by allowing your head to sink to the left.*
2. ***Stretch no. 2:*** *Allow your right ear to drop back down to your right shoulder in the same manner as before. Then slowly roll your head to the middle, until your chin touches your collarbone and your crown of the head points forward. Keep an erect spine and avoid pulling your head down with your hands – the weight of the head is just enough. Gently keep rolling your head until your left ear has reached the left shoulder. Now reverse the direction, allowing your chin to touch your collarbone again, before ending the movement on the right side where you started. Repeat a couple of times.*
3. ***Stretch no. 3 (jaw series): Note: The jaw is very fragile and can easily be hurt. It is important to perform the following exercises in a very gentle manner.*** *Stick your tongue out as far as possible without tensing your face, then bring it all the way back, sliding the tip of the tongue along the roof of your mouth. Repeat a few times. Then, with the tip of your tongue, draw circles on your lips by outlining the lips with your tongue in both directions. Repeat a couple of times. Then gently open the mouth as far as you can without moving any muscles that are not needed to do so. Close the mouth again and repeat a few times. Gently move the jaw from left to right. Keep only a little gap between the teeth. Repeat a few times. Then gently move the jaw from front to back. Keep the little gap between your teeth while repeating this a few times. Finally, rotate the jaw gently clockwise, and then in the opposite direction, this is the so-called "camel-chew". Repeat it a few times.*

Ease of equalization

Regardless of which equalization technique you are using, always aim for perfect application of the maneuver by using only the muscles involved in equalization and relaxing all others. Tensing the neck or the jaw are common mistakes making it harder for you to equalize.

In the AIDA3 course your instructor will teach you how to apply the Frenzel technique properly. An absolute imperative in this technique is to maintain a completely relaxed abdomen. The pressure needed for equalizing must solely come from your tongue (or your cheeks), while the throat is locked.

At depth, if you can hear a noise coming from your throat while equalizing with the Frenzel technique it may indicate that you are trying to support your equalization by tensing the abdomen. The sound that this creates, the so-called “Grouper call”, is a certain sign that you simply need to relax your abdomen. Do this by shifting your focus to your abdomen, allowing it to completely relax and then equalize with the Frenzel technique again. This is one of the most important ways to an efficient equalization technique at depth.

Chapter 6 - Knowledge review

There is a difference between the sensation of pressure-change and pain. Please comment.

Why is it not recommended to flush the sinuses with sea water?

Regardless of what equalization technique you are using, what should be your main focus?

CHAPTER 7

7 BAROTRAUMA

Barotrauma is a general term referring to physical damage caused by a pressure difference between an air-filled cavity in the body and the surrounding water. In diving, barotrauma most commonly occurs during descent; however, certain conditions (such as reverse block) may also cause it during ascent. It is important to emphasize from the outset that barotrauma results from improper conduct or unfavorable physiological conditions, both of which should be preventable.

Failure to equalize

Barotrauma is easy to prevent by eliminating any pressure differences acting on tissues or organs by equalizing the changing pressure. If you are not able to equalize, stop your descent! If you still do not manage to equalize completely within a reasonable time you will have to abort the dive and resurface.

Injury

Failure to equalize alone, however, does not lead to injury. Injury will only happen if you fail to equalize and still choose to descent (or ascent, in case of a reverse block) in the water column.

Stay dry until fully healed

Any barotrauma incident should be carefully assessed and appropriately treated. Medical evaluation is strongly recommended. It is also advisable to refrain from diving until full recovery, in order to reduce the risk of permanent damage.

7.1 Eardrum perforation or rupture

Injury to the eardrum is one of the most likely consequences of barotrauma, that is, if you do not abort your descent immediately when your equalization fails.

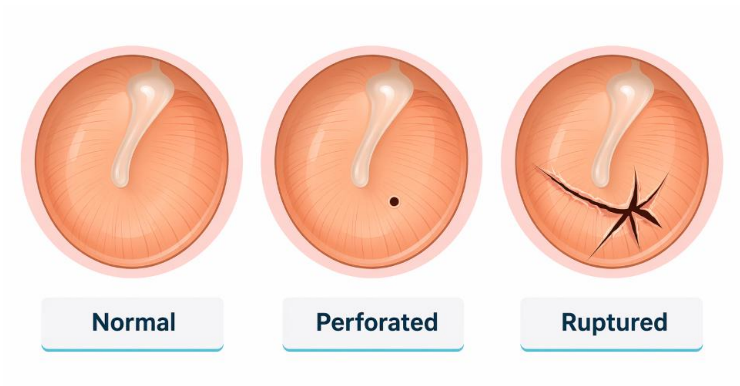


Figure 12 - Illustration of normal, perforated and ruptured eardrum

Perforated eardrum: Pinhole

A small pinhole in the eardrum, or perforated eardrum is a form of barotrauma injury.

Ruptured eardrum: Large tear

A large tear or a burst eardrum is called a rupture.

Symptoms

An eardrum perforation or rupture normally manifests itself with sharp pain. You might also experience vertigo and loss of direction. If the eardrum is damaged, there will also be a temporary loss of hearing to a certain extent. As a consequence of an eardrum injury, water may enter the middle ear, significantly increasing the risk of infection. As symptoms may not always be noticeable, another indicator of a ruptured eardrum is the presence of air bubbles escaping from the ear during equalization.

Stay dry, see a doctor

Seek medical attention to clarify the damage to your eardrum and stay out of the water until it has fully healed. An eardrum perforation can heal itself within a couple of weeks, but treatment may be necessary to prevent infections and help improve your hearing. A larger rupture or a pinhole that does not heal spontaneously might require surgical intervention.

7.2 Middle ear barotrauma

Blood forced into the middle ear

If you fail to equalize and continue your descent regardless, the increasing pressure difference can cause congestion and bleeding within the middle ear, leading to an accumulation of fluids which significantly increases the risk of infection. This condition is known as middle ear barotrauma.

Symptoms

Middle ear barotrauma can cause sharp, sometimes severe pain that may persist for several days. The ear may feel “full”, and hearing may be muffled or even temporarily lost. In some cases, as a result of a middle ear barotrauma, divers report a sensation of water in the ear the day after freediving. In some other instances, the sensation may be due to water trapped in the outer ear due to earwax. In both cases, it is recommended to seek for medical attention.

See doctor

If you experience symptoms of middle ear barotrauma, it is essential to stay out of the water and avoid any further pressure changes (e.g. flying). You should seek medical evaluation.

Healing time: One week to months

With appropriate treatment and time, this injury may resolve within a few days; however, recovery can take several months in some cases. It is therefore important to obtain medical clearance before returning to diving.

7.3 Reverse block: failure of automatic equalization during ascent

In the AIDA2 Course, you learned that there is no need to equalize during ascent. This is because, while during descent you need to deliberately introduce additional air into the body’s air-filled cavities to counterbalance the increasing environmental pressure, during ascent this air expands and is automatically released from the body. However, in rare cases, this automatic outflow may be impaired, leading to a reverse block.

Sinus or Eustachian tubes

Reverse block occurs when the Eustachian tubes (which connect to the middle ear) or the sinus ostia (openings to the sinuses) are partially or completely obstructed, preventing expanding air from escaping the affected cavity. As the air keeps expanding in an enclosed space, is it possible to experience increasing pain in the middle ear or sinuses during the ascent, which can result in lesions.

Cause and prevention

A reverse block can be caused by an acute or not fully resolved upper respiratory infection. To reduce the risk, never dive while experiencing a cold or nasal congestion. Another possible cause is the improper use of decongestant medication. Do not take any medication before diving unless advised by a doctor. Under pressure, these drugs may be metabolized more rapidly than at the surface and can wear off sooner than expected, potentially leading to airway congestion during the dive.

What to do in case of a reverse block

If the pain gets stronger upon ascent and you are not at great depth, immediately grab the rope to stop. This also helps to find orientation in case you suffer from vertigo.

You might be tempted to equalize, but remember: a reverse block is caused by too much air expanding in an enclosed space. By equalizing you would make the situation worse.

Give yourself as much time as you reasonably can. Try to remain calm and indicate to your buddy that there is a problem.

If the issue affects one ear, you can try to relieve it by stretching the neck on the affected side (e.g. if the left ear is affected, tilt your head to the right) and gently moving the jaw to promote opening of the Eustachian tube. In any event, pinching your nose and either inhaling or swallowing might help sucking the air out of the cavity.

Ascend as slowly as you can, using the rope as a guideline. The trapped air should eventually get released.

Alternobaric vertigo (AV): Unequal pressure release between the ears

Alternobaric vertigo (AV) is more commonly experienced on ascent, when one ear de-pressurizes slower (or incompletely) compared to the other. The difference in middle ear pressure can cause the brain to falsely interpret this as bodily movement. Involuntary eye movement, nausea, vomiting, tinnitus and muffled hearing can be symptoms of AV.

Note that symptoms of AV can also be caused by a temperature difference between both middle ears, or by a ruptured eardrum allowing water to flow into one middle ear.

Similar to a reverse block you should stop your ascent by reaching for the rope if you are at a shallow depth. However, at greater depths do not stop and rather keep moving slowly instead in order to not overextend your diving time. After experiencing AV, you should stop diving and see a doctor. Do not freedive before you are medically cleared and fully rested.

7.4 Hood squeeze

Well-fitting hood

A tailored wetsuit prevents water from flushing between the neoprene and the skin. The same applies to the hood: if it fits properly, water does not enter the ear canal. While this is particularly comfortable in cold-water freediving, it has a drawback—air may become trapped in the ear canal.

Air trapped in ear canal

If the hood seals tightly, air trapped in the ear canal between the hood and the eardrum may be compressed during descent, potentially causing injury to the eardrum or the ear canal. The sensation of a trapped air pocket in the ear canal may resemble a typical equalization failure, although it is a different mechanism.

Fill ears with water

To avoid having air trapped in the outer ear canal, fill your outer ear completely with water prior to every dive. You can also let water into your hood while descending. However, this might break up your streamlining and mental focus somewhat, so preferably, you have already taken care of that prior to your dive.

Warning: Do not lift your hood off your ears with a jerky movement while diving.

If there is an air pocket under pressure trapped in your ear canal, forcefully pulling on the hood can lead to ear canal or eardrum barotrauma. Alternatively, you can also pinch small pinholes in your hood, exactly at the position of your ears (while you are not wearing your suit, of course). These small holes will allow water to enter (and leave) your ear canal according to the changing pressure.

7.5 Sinus squeeze

A “squeeze” is a commonly used synonym for barotrauma, referring to a pressure imbalance between one of the body’s air-filled spaces and the surrounding environment which can result in pain or even lesions. If a partial or complete obstruction occurs in one of the sinuses or in a sinus ostium (the channel through which mucus drains from a healthy sinus), it is referred to as a “sinus block”. The causes of this condition are described below.

On descent

A fully blocked sinus will manifest very quickly during descent. Sharp pain in the forehead, behind the cheekbone, or even in the teeth may occur early as pressure increases. The pain is caused by a pressure imbalance due to failed equalization, which creates relative negative pressure within the affected sinus and prevents proper ventilation. The mucosal tissue is typically inflamed and swollen, making it highly sensitive. Diving should not be attempted in such conditions.

Blocked sinuses caused by congestion

Sometimes, a spontaneous or partial blockage of a sinus can appear while diving. The pain sets in slowly and does not go away upon equalization. This happens when old mucus temporarily blocks an ostium from a sinus towards the nose.

Stop descent or abort diving

If you experience a sinus block, stop your descent immediately by holding on to the diving line. Relax and try to equalize again: if the pain does not go away you will have to abort the dive and ascend in a controlled manner.

Check for injury

After surfacing, gently blow your nose into your hand and check the expelled mucus. If you notice any fresh blood, you may have injured the tissue in one of your sinuses. This indicates a sinus barotrauma, and you should stop diving. The injury typically resolves within a few days. During this time, you can also recover from the cold or congestion that likely caused the blockage in the first place.

In other cases, the expelled mucus after blowing your nose may appear dark brownish-red, or even almost black. This usually indicates older blood from a previous irritation or minor injury in the sinuses. In such cases, diving does not necessarily need to be stopped immediately, but it should only be continued with great caution. For example, you may perform a slow free immersion dive, remaining very attentive to any discomfort or difficulty during equalization. Regularly and carefully check whether the blockage has resolved.

7.6 Avoid blocked sinuses

The single best advice to avoid a sinus block is:

Do not dive with a cold or congestion.

Preventing common colds relies on maintaining a well-functioning immune system, supported by a healthy lifestyle, rather than on quick fixes or “magic” remedies. However, no one is completely immune, and even highly trained individuals may occasionally develop a cold. A balanced diet and reduced stress can support the recovery process.

How to avoid sinus block

Dry air, irritants, and allergies are among the most common causes of blocked sinuses. Some of these factors can be avoided. Try to minimize exposure to known allergy triggers and maintain adequate hydration to support normal mucus function. In some cases, consistent attention to these factors may help reduce the frequency or severity of sinus issues over time.

However, if symptoms persist or the cause cannot be managed, consultation with an ENT specialist (a doctor specializing in ear, nose, and throat conditions) is recommended. Short-term medical treatment of blocked sinuses may include antihistamines or decongestants. Diving should be avoided while taking these medications, as their effects may change under pressure and wear off unpredictably.

Inhale steam

Inhaling steam several times a day may help to loosen thick mucus. You can pour hot water into a bowl and inhale the steam with a towel over your head (be very cautious to avoid excessive heat on the skin), or use a dedicated steam inhaler. Sitting in the bathroom with a hot shower running is less efficient and not recommended, as it uses an excessive amount of energy.

Cleansing pranayama

Ask a qualified and experienced yoga teacher to introduce you to techniques such as *kapalabhati*, *nadi shodhana* and *bhastrika*. When practiced correctly and in appropriate conditions, these exercises may help mobilize the respiratory system and keep the nasal passages clear.

Caution: Some yogic breathing techniques involve fast, deep and/or forceful breathing. Kapalabhati and bhastrika, in particular, can create strong air movement through the nose and upper airways. For this reason, they should not be practiced during the acute phase of a cold, sinus infection, strong nasal congestion, ear pain, ear pressure or blocked Eustachian tubes. They should also be stopped immediately if they cause pain, dizziness, unusual pressure in the ears or sinuses, or discomfort. These techniques may also result in hyperventilation. They can help train and mobilize the respiratory system; however, they must not be practiced immediately before freediving.

Neti pot

Jala neti is a yogic nasal irrigation technique using a saline solution and a neti pot or similar device. Proper technique is important to avoid adverse effects. The water must be sterile, distilled, or previously boiled and cooled. It should be lukewarm and have a salinity similar to that of tears. The device must be clean, and the irrigation should be performed gently, without applying pressure.

Caution: Do not perform nasal irrigation if you have an ear infection, strong pressure in the ears, a completely blocked nostril, or recent ear or sinus surgery, unless advised by a healthcare professional. If symptoms worsen after irrigation, or if you develop fever, headache, nosebleeds or unusual pain, stop the practice and seek medical advice. Forcing water through the nostrils under pressure, for example using a squeeze bottle too forcefully or a similar device, can cause irritation, discomfort, fluid retention in the sinuses or ears, and may increase the risk of complications. Nasal irrigation should always be gentle and should never be forced.

Sleep bad side up

If you have a blocked sinus or nostril, a simple recommendation is to sleep with the affected side elevated. Mucus from an inflamed sinus drains toward the nasopharynx, and keeping the affected side higher may help facilitate this process thanks to gravity.

In contrast, if you have an inflammation of the outer ear canal, it is preferable to sleep with the affected ear facing downward to allow drainage, while avoiding any occlusion of the auricle.

Outer ear infections are more common than middle ear or sinus infections, but the symptoms may feel similar. Seek medical advice if you are unsure about the nature of the problem.

Be careful with air conditioning

Avoid excessive use of air conditioning when possible. Air conditioning systems can lower both temperature and humidity, which may dry the airways. If you cannot avoid air-conditioned environments, set the temperature to a comfortable level (typically around 26–27°C).

Keep well hydrated

As stated throughout this manual, you lose a lot of fluid while freediving through transpiration, breathing through the mouth or immersion diuresis (see Chapter 3.5). Even mild dehydration can make mucus in the sinuses thicker and impair its natural drainage.

To maintain adequate hydration, drink water regularly before, during, and after freediving. If you are freediving from a boat, make sure to have water available and begin rehydrating soon after your session, even if you do not feel thirsty. Using refillable bottles instead of disposable ones is recommended to reduce environmental impact.

Bringing a small water bottle to the float and taking small sips between dives can also help maintain hydration. Pay special attention to hydration during air travel, which often precedes freediving.

Figure 13 - Do not take risks and freedive only if you feel completely healthy

Chapter 7 - Knowledge review

How do you prevent barotrauma?

What are the symptoms of an eardrum perforation?

How does a middle ear barotrauma occur?

Why is a suspected middle ear barotrauma to be taken seriously and always be checked by a doctor?

Why should you avoid equalizing if you are experiencing a reverse block?

What is alternobaric vertigo?

A well fitting hood can be a problem when it comes to hood squeeze. Explain!

How should you react when experiencing a blocked sinus on descent to avoid a sinus squeeze?

What is the best advice to avoid a sinus block?

CHAPTER 8

8 HYPOXIA AND BLACKOUT

Blackouts are the primary reason why freediving is sometimes perceived negatively by the public. However, with proper education and training, a freediver should never approach a hypoxic state leading to loss of consciousness. Experiencing symptoms of low oxygen, such as a “samba” (LMC, see AIDA2), or a blackout (BO), reflects inadequate technique, awareness, or training, and has no place in recreational freediving.

8.1 Hypoxia

Definition

The common medical definition of hypoxia is the following:

Hypoxia is a condition in which the body or its tissues receive an insufficient supply of oxygen, typically due to a reduced partial pressure of this gas in arterial blood (see Chapter 8.3).

In freediving, we commonly refer to the oxygen saturation of the blood, often simply called "oxygenation." In a healthy person at rest, oxygen saturation while breathing normally is typically between 96–99%. In a clinical context, values below 90% are considered indicative of hypoxemia, and levels below approximately 80% are generally regarded as severe.

However, during breath-hold diving, oxygen saturation can decrease well below these thresholds without immediate symptoms. Loss of consciousness may occur at significantly lower levels—often around 45–50%—depending on individual physiology and dive conditions.

Cerebral hypoxia

Cerebral hypoxia refers to a reduction in oxygen supply to the brain despite adequate blood flow. In this condition, the circulation to the brain remains sufficient, but the oxygen content of the blood is reduced, leading to decreased oxygen delivery to brain tissue.

Consequences of cerebral hypoxia

A sustained reduction in oxygen delivery to the brain can have severe consequences, including loss of consciousness (blackout, BO; see AIDA2), brain injury, and death. As explained in AIDA2, the effects of hypoxia depend on both its severity and duration: even repeated exposure to "mild hypoxia" while remaining conscious may lead to cumulative neurological damage.

It is important to emphasize that blackout has no training value. The brain does not adapt to low-oxygen conditions through repeated blackouts; on the contrary, such practices carry significant risk and should be strictly avoided.

Mild hypoxia: Loss of motor control (LMC)

Early symptoms of cerebral hypoxia include impaired short-term memory, cognitive disturbances, and reduced motor control. In freediving, this condition is referred to as loss of motor control (LMC, see AIDA2), which typically occurs at the surface following a dive.

8.2 Ischemia

Definition

Ischemia is a shortage of blood supply to a tissue or organ, typically caused by constriction or blockage of blood vessels.

Oxygenation is ok, blood flow is not

Blood oxygenation may be normal, but the blood flow may be locally constricted, leading to insufficient perfusion of specific tissues or organs. As a result, the affected area may develop ischemia.

Cerebral Ischemia

Reduced blood flow to the brain is referred to as cerebral ischemia. From the brain's perspective, it makes little difference whether the cause is a lack of oxygen in the blood (hypoxia) or an insufficient blood supply (ischemia): in both cases, oxygen delivery to brain tissue will be compromised. Repeated or prolonged exposure to such conditions can have severe consequences.

It is therefore important to understand these two mechanisms, in order to prevent and manage them effectively.

Causes of cerebral ischemia

An insufficient blood supply to the brain may result from systemic factors, such as low blood pressure—for example when standing up too quickly. It can also be caused by external compression of blood vessels. In freediving, the most common cause of cerebral ischemia is **Arterial Gas Embolism (AGE)**.

8.3 Dalton's Law

Definition

"The total pressure of a gas mixture is equal to the sum of the partial pressures of its individual components, each behaving as if it alone occupied the entire volume."

At the surface, we breathe a gas mixture composed of approximately 79% nitrogen and 21% oxygen, corresponding to partial pressures of about 0.79 bar and 0.21 bar, respectively.

For humans, the safe range of oxygen partial pressure is generally considered to lie between approximately 0.16 bar and 1.6 bar. However, as with all physiological limits, the effect depends on exposure: our response to extreme oxygen partial pressures is strongly influenced by both their magnitude and the duration of exposure.

8.4 Shallow water blackout

A shallow water blackout is a form of pressure-related hypoxia occurring during ascent. The term is sometimes used inconsistently: some organizations and individuals apply it to any loss of consciousness occurring in shallow water, such as in a swimming pool or even a bathtub. In freediving, however, the term has a specific and precise meaning, which can be summarized as follows:

1. Loss of consciousness caused by hypoxia occurring towards the end of a dive.
2. The hypoxic condition is caused or exacerbated by changes in ambient pressure (particularly during the ascent).

Descent increases partial pressure of oxygen

Figure 14 shows how a shallow water blackout may develop. During descent, the lungs are compressed as ambient pressure increases. This raises the partial pressure of oxygen in the lungs, creating a steeper gradient between the lungs, blood, and tissues, thereby facilitating efficient oxygen transfer to the tissues (see diffusion in Chapter 2.2).

Ascent reduces diffusion gradient

After reaching the target depth and beginning the ascent, however, ambient pressure decreases, leading to a reduction in the partial pressure of oxygen (O_2) in the lungs. As a result, the gradient in O_2 partial pressure between the lungs, blood, and tissues becomes less steep. In extreme cases, this gradient may even reverse.

In the final meters of the ascent, oxygen may be redistributed from the tissues back toward the lungs as the body attempts to equilibrate the decreasing O_2 partial pressure, potentially leading to a critical reduction of oxygen available to the brain.

Unconsciousness at an average of 0.1bar ppO_2

Most people lose consciousness when ppO_2 falls below approximately 0.1 bar. As a result, a diver who remains above this threshold at depth due to the increased ambient pressure will experience a sudden drop below it during ascent, which may lead to a shallow water blackout. A ppO_2 of 0.18 bar at 10 meters can fall below the critical threshold at four meters from the surface, making loss of consciousness highly likely.

The closer to the surface, the greater the relative drop in pressure

The risk of shallow water blackout is greatest in the final meters of the ascent, where the relative change in pressure is most pronounced. From 30 m (4 bar) to 20 m (3 bar), the pressure decreases by only 25%, whereas between 10 m (2 bar) and the surface (1 bar), it decreases by 50%.

In-depth: Shallow water blackout *(conceptual model and data by Francesco Corucci. Visualization inspired by Marcell Bago).*

The figure below represents a simplified model of a shallow water blackout (explanation below).

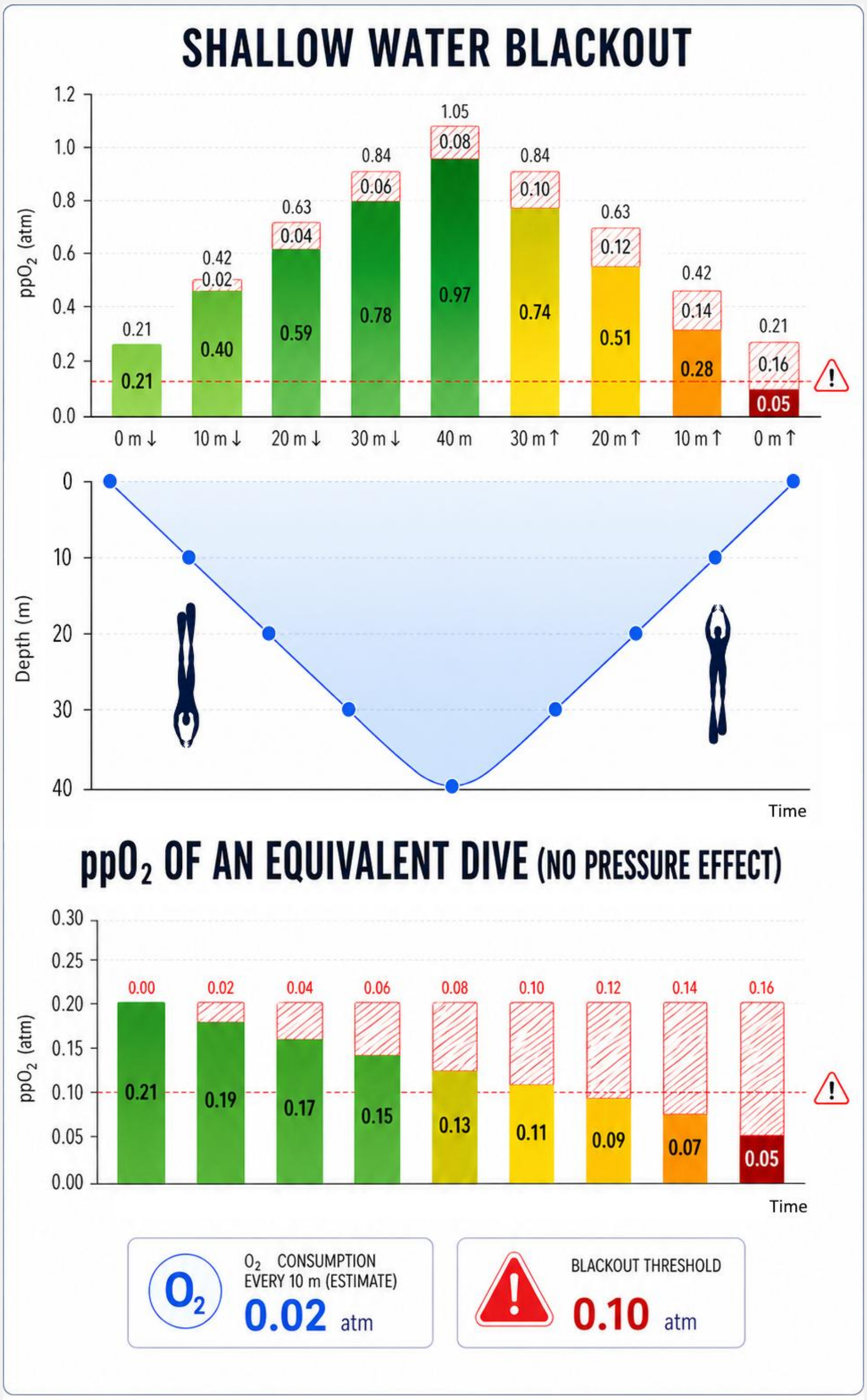


Figure 14 - Simplified model of shallow water blackout.

Metabolic O_2 consumption is represented as a linear decrease in ppO_2 (−0.02 atm per step). Bar colors indicate ppO_2 trends, red dashed bars represent O_2 consumption during the dive, solid bars represent a realistic, net ppO_2. The risk of blackout is primarily driven by the rapid drop in ambient pressure during the final phase of the ascent, which causes a steep reduction in oxygen partial pressure. Top: During descent, increasing ambient pressure leads to a rise in ppO_2 despite ongoing oxygen consumption. During ascent, ambient pressure decreases—most dramatically in the last meters (it halves in the final 10 m)—causing a rapid fall in ppO_2. Combined with continued metabolic consumption towards the end of the performance, this explains the high risk of shallow water blackout near the surface. Bottom: ppO_2 during an equivalent dive without pressure changes (e.g. static or dynamic apnea). Without the effects of depth, the same oxygen consumption would lead to an earlier drop in ppO_2 below critical levels (at a stage of the performance roughly equivalent to the 20-30m range in the deep dive at the top).

Role of safety divers

This explains why the final 10 meters of the ascent are the most critical phase of a freedive and highlights the importance of safety divers. Most incidents, if any, occur close to the surface.

Accordingly, standard AIDA procedures require a safety diver to meet the diver at a depth of at least 10 meters. For deeper dives, it is recommended that the safety diver meets the diver at greater depth, accompanying them during approximately the final third of the ascent.

You can learn more about state-of-the-art safety protocols for freediving competitions (Figure 15) in dedicated specialty courses, such as the ***AIDA Competition Safety Freediver*** course series. Please find more details on these courses on the AIDA website.

Figure 15 – Safety divers in action during a competition.

8.5 Decompression illness and surface intervals for freediving

Until recently, decompression illness (DCI) was thought to affect only divers breathing compressed gas, such as in scuba or technical diving. These divers inhale significant amounts of nitrogen (N_2) under increased pressure. If ascent is too rapid, the dissolved nitrogen may come out of solution and form bubbles in the blood and tissues. These bubbles can impair circulation and lead to tissue damage.

However, the evolution of freediving has provided evidence that DCI can also affect breath-hold divers. As freediving is still a relatively young scientific field, our understanding continues to evolve. It is not yet fully established how much nitrogen a freediver absorbs at different depths and durations. Observations over the past decades suggest that both nitrogen uptake and susceptibility to DCI can vary significantly between individuals, depending on multiple factors.

Note: DCI encompasses two different action mechanisms, known as *decompression sickness (DCS)*, and *arterial gas embolism (AGE)*. These will be described in greater detail in the ***AIDA4 Master Freediver course***.

Signs and symptoms of DCI

Below you can find a list of symptoms that may indicate DCI:

- Prolonged fatigue
- Pain in arms, legs or torso
- Dizziness or vertigo
- Shortness of breath or painful breathing
- Local numbness, tingling or paralysis

As a buddy, you can observe the following signs in the diver, potentially indicating DCI:

- Blotchy skin rash
- Rubbing joints
- Staggering
- Coughing spasms
- Collapse
- Unconsciousness

If you experience any or several of these symptoms or signs, immediately stop freediving and seek medical assistance. If available, breathe pure oxygen until you reach the closest medical facility.

Rules of thumb

In your AIDA3 course, you are allowed to dive as deep as -30m. To calculate a safe surface interval for these depths you can use a simple rule of thumb:

- Freediving up to 30m: ***surface time = 3 * dive time***

Let’s say you dove to 25m in 1:10, you should then rest at the surface for at least 3*1:10=3:30, before your next dive.

For dives deeper than -30m, two different rules apply. These rules are discussed in detail in the AIDA4 course, but are reported below for completeness:

- Freediving to 30-55m: ***surface time = 6 * dive time***
- Freediving deeper than 55m: ***one dive in 24h***

These rules of thumb are intended to provide a substantial safety margin and help reduce the risk of developing symptoms of decompression illness. However, nitrogen accumulation is also influenced by factors such as the number of dives performed, as well as individual characteristics including fitness, overall health, and other variables.

Divers should therefore remain vigilant and respond promptly to any unusual signs or symptoms.

Chapter 8 - Knowledge review

Why is there no benefit in intentionally inducing a blackout?

Provide examples of how cerebral ischemia can occur.

What is the meaning of the term “shallow water blackout” in freediving?

Decompression illness occurs only in divers who breathe compressed gas, such as in scuba diving. True or false? Explain your answer.

CHAPTER 9

9 TRAINING CONCEPTS

At first glance, freediving training exercises—structured sequences of breath-holds often referred to as “*tables*”—may all appear similar: dynamic laps with varying distances and recovery times, or a series of static breath-holds. Yet, similar combinations of effort and recovery can serve very different training objectives.

In practice, three main types can be distinguished:

1. **Warm-up tables**: Designed to prepare the diver for a single maximum-performance attempt.

2. **CO_2 tolerance tables**: Designed to improve tolerance to elevated carbon dioxide levels.

3. **O_2 training tables**: Designed to improve the ability to function under low oxygen conditions (<u>not used in recreational freediving</u>).

Each table should have one main training goal and should not deliberately combine high CO_2 stress with low-O_2 exposure in the same recreational exercise.

In this course, you will learn how to apply the first two concepts and adapt them to your individual needs. As these vary depending on experience level and personal characteristics, it is rarely effective to simply copy a table designed by someone else. Instead, you should develop your own.

By applying these principles, performance can improve rapidly, requiring regular adjustments to maintain an appropriate level of challenge and ensure continued training effectiveness.

9.1 Warm-up to max performance

Allow time for the body to enter "freedive mode"

Before a maximum-performance attempt, the body and mind need time to transition into a state of relaxation and readiness often referred to as "freedive mode." This state is achieved by allowing the muscles to relax, the heart rate to settle, and the breathing pattern to become calm and controlled.

The extent of the warm-up required depends on several factors, including experience level, prior physical activity, stress, and individual characteristics. In open water, warm-ups typically consist of a series of slow, shallow, and relatively short dives. In the pool, they usually involve a sequence of short breath-holds.

Throughout the warm-up, the diver remains focused on relaxation and the upcoming dive, minimizing external distractions.

Physical and mental relaxation

The primary purpose of warm-up is to induce both physical and mental relaxation. These two aspects are closely linked and reinforce each other: a calmer mind promotes physical relaxation, which in turn further quiets the mind.

As discussed in AIDA2, focusing on physical stillness through a structured relaxation technique is an effective way to achieve this state. Maintaining attention on the relaxation process itself helps prevent the mind from wandering.

During warm-up dives, awareness remains anchored in the present moment. In the final relaxation phase before the maximum attempt, visualizing each phase of the dive can further enhance mental preparation (see below).

Inducing the mammalian dive response

In addition to mental preparation, warm-up dives help trigger the MDR (see Chapter 3) making the sensations associated with the activation of this physiological response feel smoother and more gradual.

Visualization as part of preparation

Visualization is a powerful tool and can be used as a complement to physical warm-up. Entire dives can be mentally rehearsed in detail: from the duck dive, to body position and equalization, to propulsion and ascent, finishing with proper recovery breathing and signaling. Visualization is so powerful that competitive athletes may use very little or no physical warm-up before a maximum attempt. This approach requires lots of experience, flexibility, and confidence, both in terms of equalization and mental attitude. It is not a skill taught or practiced during AIDA3 courses, and it should not be considered a recommended method for recreational freediving.

For AIDA3 students, especially in open water and depth training, every dive should be approached progressively, using appropriate warm-up dives, adequate surface intervals, and direct instructor supervision.

Figure 16 - Warm-up dives are often done in free immersion (FIM)

"Save the legs" approach

One of the limiting factors in constant weight freediving is the tolerance of the active muscles, primarily the legs, to lactic acid accumulation toward the end of a dive. Once this tolerance is exceeded, muscle performance may be significantly impaired, and legs may feel "heavy".

For this reason, warm-up dives should be performed with minimal physical effort to avoid unnecessary lactate accumulation. Free immersion (FIM) is therefore the preferred technique for warm-up, as it allows the diver to move along the line in a slow and controlled manner while maintaining overall relaxation. This approach enables longer dive times with minimal muscular strain and reduced lactate production.

Examples of warm-up tables

The table below shows a typical example of a warm-up table for a maximum attempt in static apnea (STA). Using time references as a guide for warm-up may not always match the body's needs on a given day. For example, a three-minute breath-hold may feel easy on one day, while on another it may already push your limits.

For this reason, it can be more effective to use the onset of the first contraction as a reference point. Contractions are triggered at a relatively consistent level of carbon dioxide (CO_2) in the blood and therefore provide a more individualized indicator of effort, helping to prevent excessive strain during the warm-up phase.

Relaxation	Breath hold
3 min	First contraction
3 min	First contraction
3 min	First contraction
6 min	Maximum performance

Figure 17 - Example for a warm-up table in static apnea (STA)

However, it is important to note that the timing of the first contraction is not entirely fixed. Factors such as stress or insufficient relaxation may cause contractions to occur earlier than usual. This does not diminish the usefulness of this method; rather, such variability can provide valuable insight into the diver's current state.

Once your warm-up table has been prepared, it should be shared and discussed with your buddy. The buddy then guides you through the entire warm-up sequence, providing time cues (e.g. during static breath-holds) and reminders about the structure of the next repetition.

> ***Example**: "Up next is your fourth static, during which you will go to first contraction and then try to go on holding your breath while I count down one minute for you. You have two and a half more minutes to relax, enjoy your time. My next announcement will be at the 2-min mark."*

With experience, you will learn which warm-up sequence works best for you. Some freedivers prefer several short and easy warm-up dives, while others use fewer repetitions. Some top-level athletes may perform their dive with no warm-up at all.

There is no single "best" warm-up table, but every warm-up plan must prioritize relaxation, gradual progression, adequate recovery, and safety. At AIDA3 level, warm-up routines should remain conservative and should be adapted under the guidance of your instructor.

The warm-up as shown in below is a commonly used table in competitive DYNB freediving. Most of the relaxation is performed outside the water, before the table begins. Once the athlete enters the water, only about 10 minutes remain before the maximum attempt is performed.

Reducing time spent in the water allows the freediver to use the thinnest possible wetsuit (or none at all) without getting cold.

Relaxation	STA/DYNB
3 min	Dry STA to first contraction
3 min	Dry STA to first contraction + 20s
3 min	DYNB 25m
5 min	Maximum performance

Figure 18 - Warm-up table for DYNB

Another choice is that of mixing static and dynamic during warmup. In this approach, the diver performs a static breath-hold for a set duration (timed by a coach or buddy), followed immediately—without breathing/recovery—by a DYNB dive over an easy distance. After this sequence, sufficient recovery time is essential before the maximum attempt.

Relaxation	STA/DYNB
3 min	1min STA + 25m DYNB (no breathing in between)
5 min	Maximum performance

Figure 19 - Warm-up table including STA-DYNB

As in dynamic apnea, it is equally important to conserve energy in the legs before a maximum attempt in constant weight (with fins). For this reason, warm-up dives are typically performed using free immersion (FIM), pulling along the dive line.

This approach minimizes physical effort, as movement is limited to the pulling action while the rest of the body remains fully relaxed.

Relaxation	Pull downs (FIM)
3 min	Slow FIM to -10m, (or neutral buoyancy), then pull up slowly
3 min	Slow FIM to neutral buoyancy depth, hang to first contraction, pull up slowly
3 min	Slow FIM to neutral buoyancy depth, hang to first contraction+20s, pull up slowly
5 min	Maximum performance

Figure 20 - Warm-up table for a max- attempt in constant weight.

For this type of warm-up, the freediver may need to use a watch to time the second phase, which is not always ideal. As in static apnea (STA), the onset of the first contraction can instead be used as a reference to gauge the duration of the “hang” at depth. From that point onward, a simple mental countdown is sufficient.

Counting mentally is generally accurate enough, as warm-up tables do not require high precision but should prioritize relaxation. It is important to adjust the table to individual needs, preferences, and training goals.

As with training tables (see section 9.2), warm-up tables are highly individual and often develop into a routine—or even a ritual—through repeated practice. However, it is important not to become overly dependent on this routine. A successful maximum attempt does not rely on a perfect warm-up sequence: relaxation ultimately comes from within the diver, not from the table itself.

Figure 21 - Freedive competitions are the ultimate test for "maximum attempts"

9.2 CO_2 training tables

Tolerance to CO_2

A CO_2 table is structured so that carbon dioxide levels in the body progressively increase with each breath-hold, despite the recovery period in between. The purpose of this type of training is to improve tolerance to elevated CO_2 levels, both physically and mentally.

Static or dynamic

CO_2 tables can be performed in complete relaxation (static) or while being physically active (dynamic, swimming or even jogging – see AIDA4 for more training concepts). When performed dynamically, this type of training also contributes to improving muscular tolerance to lactate.

Wet or dry

CO_2 training can be conducted in dry conditions—for example while lying relaxed on a bed (static) or walking (dynamic). It can also be performed in a pool or confined water. However, **remember that any breath-hold training in water must always be conducted under proper supervision.**

A qualified buddy must be present and actively monitoring the diver at all times (Figure 22). Training side by side is not sufficient as a safety procedure: one diver performs the breath-hold while the other remains fully attentive and ready to assist, then roles are switched.

Figure 22 - Buddy team in static apnea (STA)

No hypoxia

A well-designed CO_2 table is challenging due to the progressively increasing levels of carbon dioxide in the body. Recovery periods between breath-holds are long enough to restore adequate oxygen levels, but not sufficient to fully eliminate excess CO_2.

As a result, CO_2 accumulates over the course of the table, increasing the level of discomfort, while oxygen levels remain sufficient to avoid hypoxic conditions.

Design Principle 1: Constant breath-hold duration

Each diver has an individual breath-hold capacity and CO_2 tolerance, which means training tables are most effective when tailored to personal needs.

The first fundamental design principle is that breath-hold duration remains constant, while recovery time is progressively reduced. In a classic CO_2 table, the breath-hold duration is fixed, and the breathing intervals become shorter with each round.

Design Principle 2: Approximately 50% of max STA

To design your first CO_2 table according to this principle, you should first determine your current maximum static apnea (max STA), for example using a warm-up table.

Once established, use approximately 50% of your max STA as the breath-hold duration for your CO_2 table. For example, if your max STA is 3 minutes 20 seconds, a suitable starting point would be breath-holds of 1 minute 40 seconds.

Relaxation	Hold
2:00	2:00
1:45	2:00
1:30	2:00
1:15	2:00
1:00	2:00
0:45	2:00
0:30	2:00
0:15	2:00

Figure 23 - Example of a STA CO_2 tolerance training table, based on time

Design Principle 3: Eight STA or 20 DYNB breath-holds

A classic static CO_2 table typically consists of around eight relaxed breath-holds. In a dynamic table, however, the diver is physically active and therefore produces more CO_2. As a result, breath-hold durations must be shorter than in static tables to avoid excessive fatigue and maintain control of technique.

To compensate for the shorter breath-holds while still achieving a strong CO_2 stimulus, dynamic CO_2 tables are usually designed with a higher number of repetitions. Increasing the number of rounds allows CO_2 to accumulate progressively over time, creating the desired training effect without requiring long or overly demanding individual efforts.

In the CO_2-table shown below, for example, you will repeat every distance for four times, with decreasing recovery time between each set, resulting in a total of 20 repetitions.

Breath	Distance	Repetitions
1:15	25m	4
1:00	25m	4
0:45	25m	4
0:30	25m	4
0:15	25m	4

Figure 24 - Example of a Dynamic CO_2 table, based on several sets with decreasing recovery

Time-based tables

If you perform a static apnea (STA) table in dry conditions, for example while relaxing on your bed, timing is straightforward using a stopwatch or a dedicated app. Many apps allow you to program or automatically generate training tables and guide you through the sequence with audio cues, similar to a buddy.

Remember that any breath-hold training performed alone must always be done outside of water.

If you choose to train in water, a qualified buddy must be present at all times. In this case, the buddy can guide you through the table, taking responsibility for timing and managing repetitions.

Count-based tables (breaths, steps, etc.)

All tables discussed so far are based on time (seconds and minutes). However, an alternative and highly effective approach is to structure tables based on counted actions, such as breaths or steps, rather than time.

For example, instead of breathing for 30 seconds, you may take five breaths. This is a perfectly viable and consistent method, as one full breath represents a well-defined volume of air (Chapter 4) and is easy to reproduce.

In fact, in time-based tables the actual amount of air exchanged can vary significantly: 20 seconds of relaxed abdominal breathing (tidal volume, TV) is very different from 20 seconds of full ventilations using you full vital capacity (VC). Counting breaths therefore provides a more precise and controlled way to structure CO_2 tables.

Relaxation	Hold
8 breaths	2:00
7 breaths	2:00
6 breaths	2:00
5 breaths	2:00
4 breaths	2:00
3 breaths	2:00
2 breaths	2:00
1 breaths	2:00

Figure 25 - Example of a static CO_2 training table based on breath count

Jogging while breathing	Jogging on breath hold	Repetitions
30 steps	50 steps	4
25 steps	50 steps	4
20 steps	50 steps	4
15 steps	50 steps	4
10 steps	50 steps	4

Figure 26 - Example of a dynamic CO_2 training table, based on step-counts

Count-based methods are particularly useful for dynamic training, where timing may be impractical. For example, in a "walking apnea" table, you may breathe for 10 steps and then hold your breath for 30 steps. This allows for effective dry CO_2 training without relying on time measurement.

A similar approach can be applied in the pool. For instance, a dynamic table might consist of 5 breaths followed by a 25 m DYNB dive, then 4 breaths and another 25 m dive, 3 breaths and 25 m, and so on.

Adjusting your CO_2 table

Once you understand the structure of a CO_2 table, you can adapt it to your level and training goal. The key is to change the table intentionally, rather than randomly making it harder.

A CO_2 table can be adjusted by changing one main variable at a time: the duration or distance of the breath-hold, the recovery time, the number of recovery breaths, the number of repetitions, or the intensity of the movement in dynamic exercises.

Each change affects the exercise differently. Shorter recoveries or fewer recovery breaths usually increase CO_2 accumulation. More repetitions increase the overall training volume. Higher movement intensity increases CO_2 production and muscular fatigue. Stopping the breath-hold at an internal marker, such as the first contraction or a small, fixed number of contractions, can make the table more individualized, but it also makes the exercise more dependent on relaxation, stress and daily condition.

For AIDA3 recreational training, the goal is to create a controlled, repeatable and manageable CO_2 stimulus. Change only one main variable at a time, keep the table relaxed and technically clean, and avoid turning every session into a maximum effort.

In-depth: understanding contractions

Freedivers often refer to "diaphragmatic contractions", but this term does not tell the whole story. The sensation may involve different respiratory muscles, including diaphragm, but also intercostal muscles and abdominal muscles. Different freedivers may perceive contractions in different areas, and the same freediver may experience them differently depending on lung volume, relaxation, posture and training state.

Contractions are part of the body's automatic attempt to resume breathing. They are strongly influenced by rising CO_2, but they are not caused by CO_2 alone. Breathing is controlled by the respiratory centers in the brainstem, which receive information from several pathways: chemical signals such as CO_2-related acidity and low O_2, and mechanical signals such as lung volume and respiratory muscle activity.

In normal breath-hold training, CO_2 is usually the earliest and most relevant trigger for respiratory drive. This is why contractions are commonly used as a practical reference point in CO_2 training. However, the first contraction should not be treated as a perfectly fixed marker. Stress, poor relaxation, fatigue, different lung volumes or different body positions may all change when and how contractions appear.

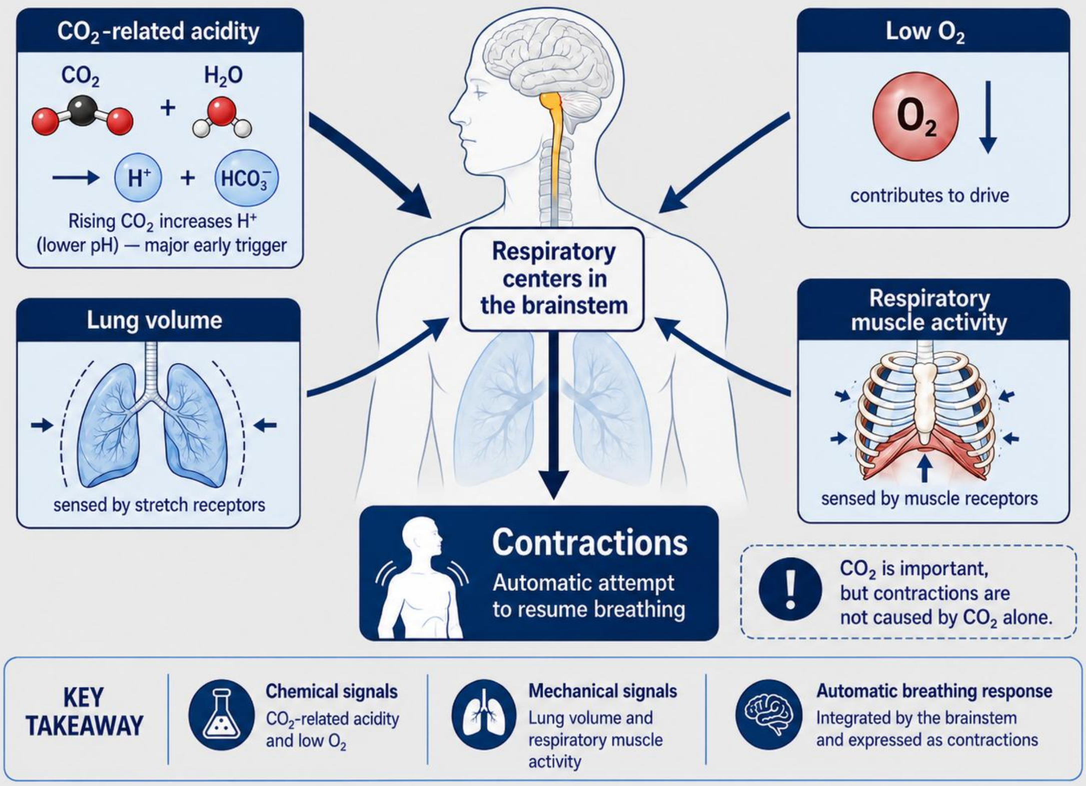


Figure 27 - Contractions are not triggered by CO_2 alone.

<u>Awareness exercise</u>

During static practice, notice where contractions are felt: diaphragm, abdomen, rib cage, throat area, or a combination of these. Under instructor guidance, students may also compare how contractions feel after a comfortable full inhalation and after a passive exhalation. Lower lung volumes may make contractions appear earlier or feel different, and can partly simulate the reduced lung volume experienced at depth due to Boyle's law.

9.3 O_2 training tables

After CO_2 tables, many freedivers also hear about "O_2 tables". This traditional term usually refers to tables in which the breath-hold duration or swimming distance gradually increases, while the recovery between repetitions remains long enough to feel complete. For example, a static O_2 table may use progressively longer breath-holds with the same recovery time between each repetition. In dynamic apnea, the same principle may be applied by progressively increasing the distance while keeping a comfortable recovery.

The goal of these traditional O_2 tables is to become more familiar with longer breath-holds or longer distances, not to deliberately create dangerous low-O_2 states. Depending on how the parameters are selected, these tables can be practiced safely in a recreational context, provided that they remain well within non-hypoxic limits.

It is important to distinguish traditional O_2 tables from hypoxic or low-O_2 tolerance training. With a high tolerance to CO_2, it becomes possible to extend breath-hold duration to the point where hypoxia may occur toward the end of a dive. To some extent, body and mind can be trained to function under these conditions. However, this type of training can be risky and is not part of recreational freediving practice.

In recreational freediving, the goal is to avoid situations in which symptoms of low oxygen occur. There is absolutely no gain in exposing yourself to repeated hypoxic states, loss of motor control, or blackout.

The term "O_2 table" should also not be understood as the exact physiological opposite of a CO_2 table. CO_2 tables work because, after a non-extreme breath-hold, blood oxygenation recovers relatively quickly, while CO_2 takes longer to be eliminated. Short recovery times can therefore allow CO_2 to accumulate from one repetition to the next, while O_2 remains close to normal values.

The opposite mechanism is not equally achievable in safe practice. To progressively lower O_2, the diver must hold the breath; however, during every breath-hold, CO_2 is inevitably produced as well. If the recovery is long enough to clear CO_2, O_2 also returns toward normal. If the recovery is too short, the exercise becomes both hypoxic and hypercapnic.

For this reason, traditional O_2 tables are better understood as progressively longer breath-holds or distances with sufficient recovery, rather than as a method to isolate low-O_2 adaptation.

Low-volume breath-holds, such as passive-exhale or residual-volume breath-holds, can make low-O_2 states appear sooner because the breath-hold starts with a smaller lung gas reservoir. However, they are still not a pure "O_2 training" method: CO_2 continues to accumulate during the breath-hold, and low lung volume can also increase respiratory drive through mechanical signals, making contractions appear earlier or more strongly. These exercises belong to more advanced training contexts and should only be practiced under qualified guidance.

If you experiment with traditional O_2 tables, always stop well before any hypoxic symptom appears.

9.4 Diversify training

One way to make your training more fun and effective is to train different disciplines. In addition to the already mentioned dynamic with bifins and statics, other disciplines such as no-fins or monofin can be used to spice up your training. Most of them, however, require specific technical training.

If you are interested in monofin technique (Figure 28), for example, you can have a look at the ***AIDA Monofin Freediver*** course series.

Figure 28 - A freediver diving with a monofin.

Chapter 9 - Knowledge review

What is the “save the legs” approach?

What is the rationale of a CO_2 table?

CHAPTER 10

10 AIDA GREEN: FREEDIVERS FOR THE ENVIRONMENT

10.1 One Ocean

As freedivers, we are often among the first to witness the consequences of environmental change in the Ocean. AIDA Green encourages all freedivers to act as ambassadors for the Ocean.

In this material, the word "Ocean" is used in a broad sense and refers to the Earth's interconnected water systems, including seas, rivers, and lakes.

The Ocean is a crucial component of the global ecosystem and is heavily affected by human activities such as pollution, overfishing, and tourism. Although freediving is a gentle way to approach the underwater world and marine life, our behavior still has an impact.

This chapter builds on the rules of conduct introduced in AIDA1 and AIDA2. The information presented here is not only useful in the classroom: it can help you integrate environmental awareness and a deeper understanding of the aquatic environment into your diving, training, and lifestyle. In doing so, each of us can contribute to protecting the health of the Ocean.

Figure 29 - Freedivers often live in tight symbiosis with the Ocean, and can more easily recognize changes in the environment.

10.2 State of the Ocean

Pollution

Enormous amounts of debris and pollutants end up in the ocean with severe consequences on all marine ecosystems. Among them, scientists registered a generalized loss of biodiversity, widespread habitat deterioration, expansion of oxygen depletion zones, acidification, coral bleaching and extinction of certain species.

The main contributors to Ocean pollution are:

- Industrial discharges (both legal and illegal).
- Human activities on land (disposal of garbage and waste products, coastal development etc.).
- Animal farms discharges (causing the expansion of oxygen depletion zones in the ocean).
- Agrochemical runoffs (fertilizers, herbicides and pesticides).
- Plastic trash.
- Oil spills.
- Dumping of waste products/materials.
- Sewage.
- Particles in the air (waste products, gas emissions).
- Light pollution caused by coastal towns and cities. This disrupts natural rhythms of migration, mating or feeding times.

- Noise pollution. Human generated noise deriving from fracking, drilling, large ships engines and air gun seismic tests for oil search are increasing, modifying the underwater acoustic landscape. The impact on cetaceans and other marine animals is tremendous, and it includes deafness, lack of orientation, disruption of hunting and mating patterns, stranding and death.

Figure 30 - Trash found at the bottom of a body of water.

Trash

Plastic debris enters waterways and eventually finds its way into the Ocean. In some cases, it is dumped directly into aquatic environments. The presence of plastic waste in the Ocean is a consequence of the enormous amount of plastic used worldwide (Figure 31). Our consumption of plastic continues to increase, and today plastic is present in almost every aspect of daily life.

The overuse of plastic is partly linked to the lack of pressure on industries and governments to develop and adopt better alternatives. Without clear expectations from society and the global community, companies and governments may feel little responsibility for the environmental consequences of their material choices.

At the same time, many regions lack adequate infrastructure for collecting, sorting, recycling, or safely disposing of plastic waste. Even where disposal facilities exist, littering and improper waste management further contribute to the problem.

Ocean-based sources of plastic waste, such as ghost nets (abandoned fishing gear), pose a significant threat to the ocean, trapping both animals and debris.

Single-use plastics items (grocery bags, water bottles, straws, food containers, napkins, earbuds, cutlery and cups) remain in the environment, breaking down into microplastics and releasing toxins into the ecosystem (Figure 33).

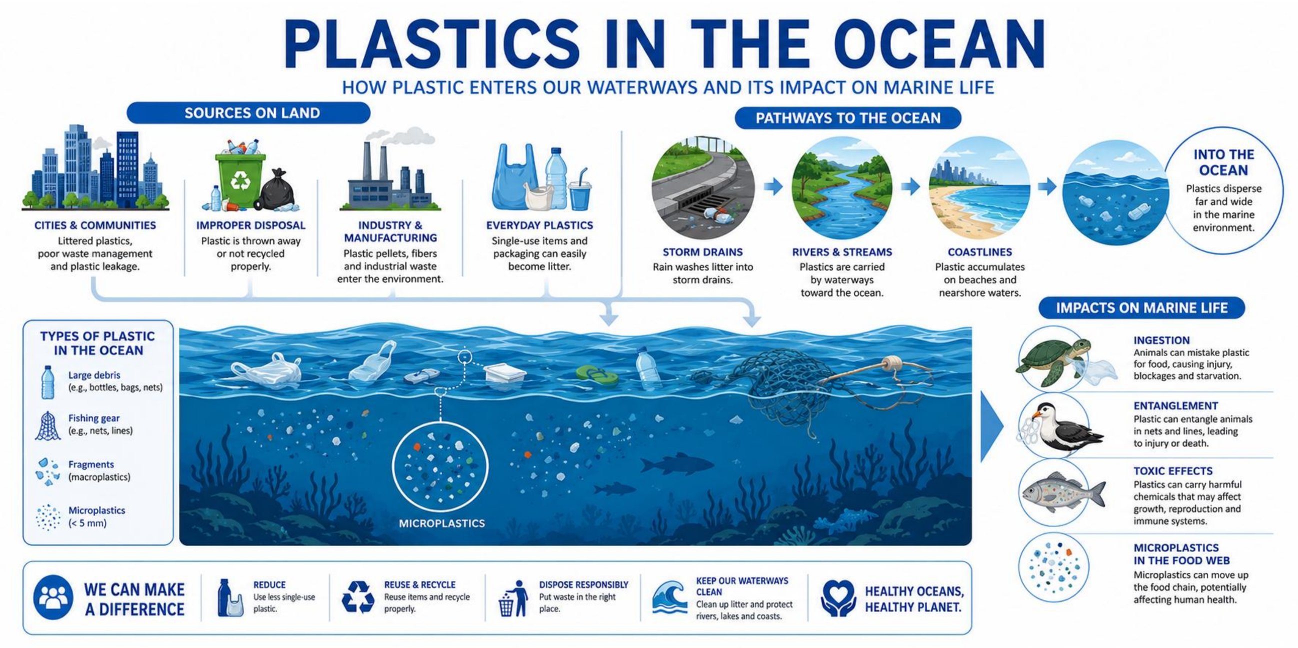


Figure 31 - Infographic: plastics in the Ocean

Approximately 8 million metric tons of plastic items thrown away each year are not recycled. They end up in the ocean, polluting the water and killing marine life through ingestion or entanglement.

It is not only the environment that is affected: the consumption of marine organisms contaminated with plastics can cause serious health issues for humans as well (Figure 34). Marine organisms accumulate increasing levels of toxic substances as they move up the food chain. Approximately 50'000 particles of microplastic are consumed by each human per year, and this number may be underestimated due to a small sample size[1].

[1] Kieran D. Cox, Garth A. Coverton, Hailey L. Davies, John F. Dower, Francis Juanes & Sarah E. Dudas. *Human Consumption of Microplastics* (Environmental Science & Technology 2019)

Figure 32 - Various plastic debris floating in the Ocean.

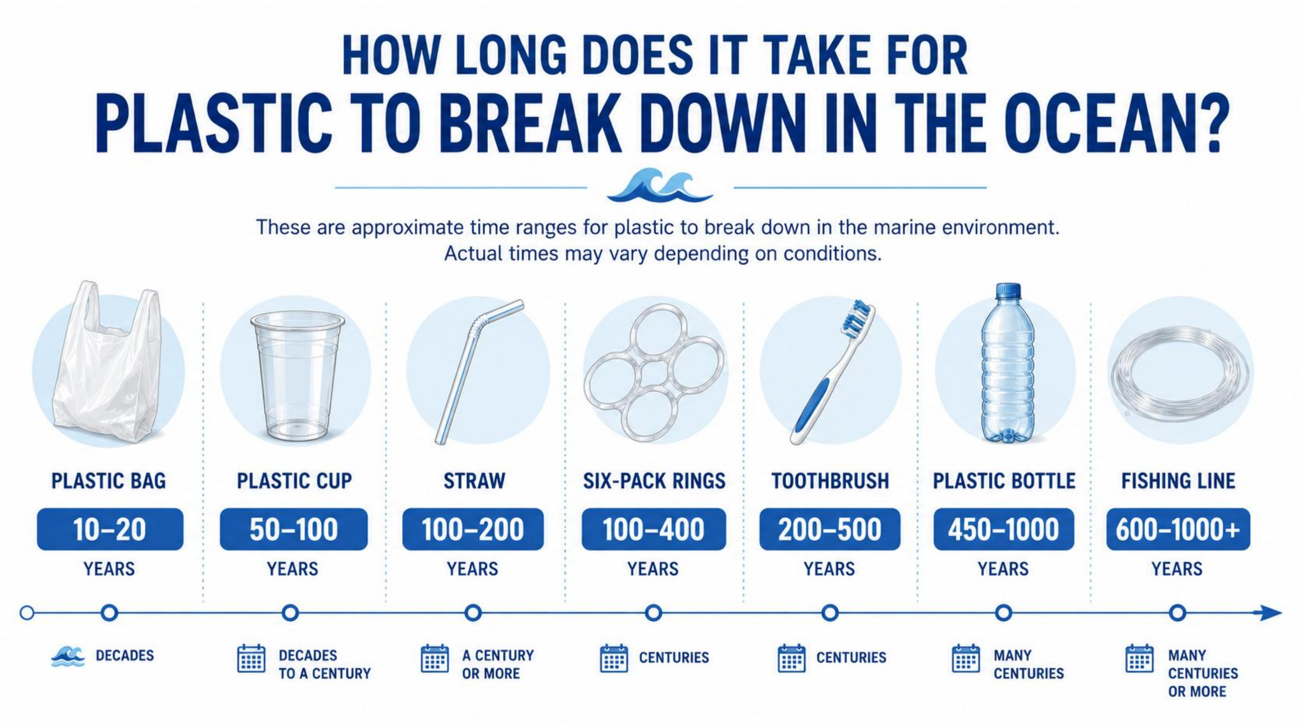


Figure 33 - How long does it take for plastic to break down in the Ocean.

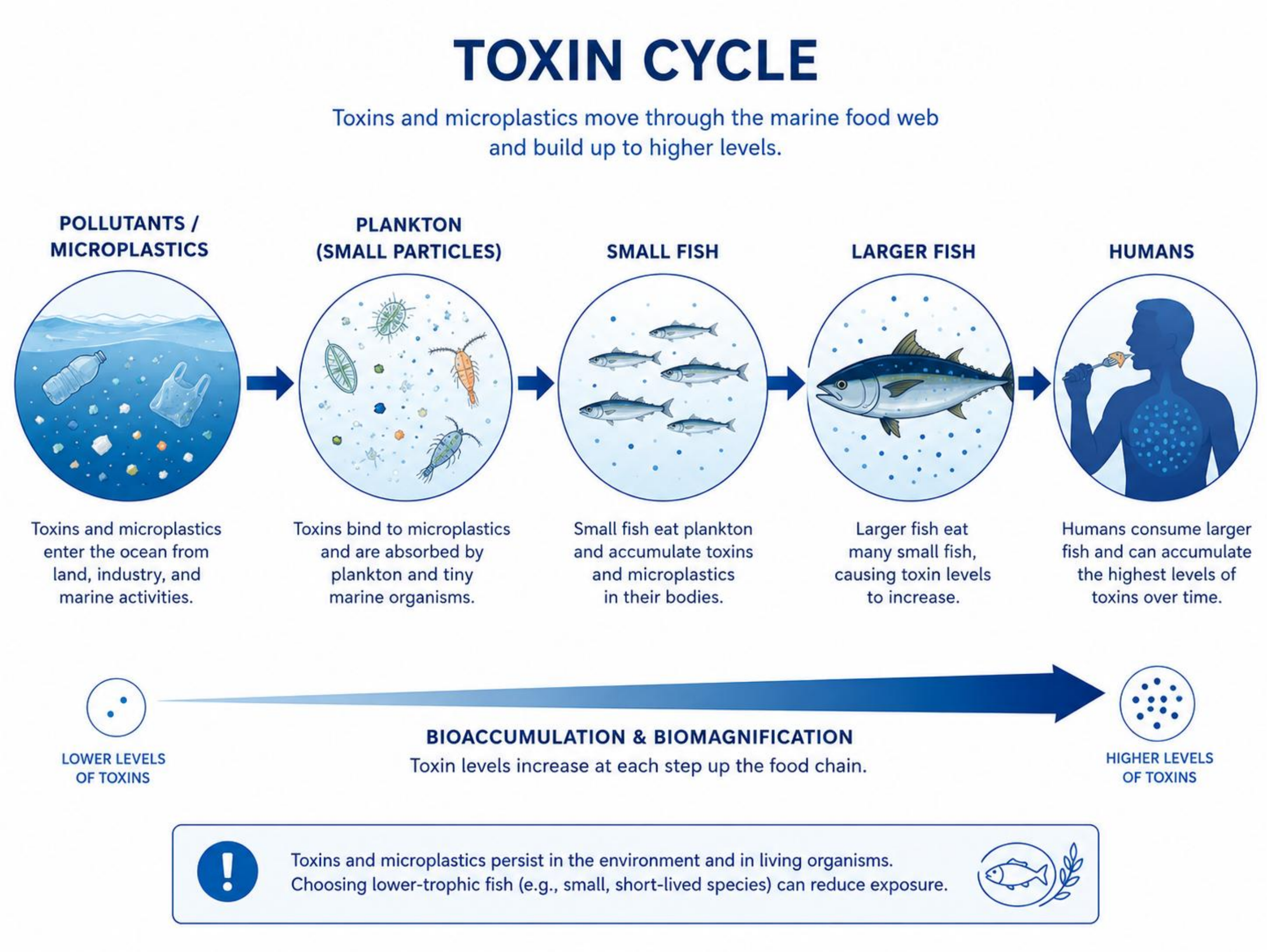


Figure 34 - Toxin's cycle.

10.3 Tourism

Unsustainable tourism

Tourism can provide employment and economic benefits for host countries and local businesses. However, in areas affected by mass tourism, it can be difficult to control business activities and limit their impact on the environment (Figure 35).

Tourism may support the development of a destination, but if local communities are not meaningfully involved or provided with fair employment opportunities, much of the profit may remain with private companies rather than benefiting local society.

The natural ecosystem can also be seriously affected. Air quality, water, soil, vegetation, and wildlife may all suffer as a result of poorly managed tourism.

Figure 35 - A tourist mindlessly standing on a fragile coral reef.

Mass tourism affects primarily:

- Beaches (e.g. pollution, damage to coral reefs, and disturbance to marine life).
- Cliff-sides (e.g. over-construction and trash).
- Degradation of the landscape (e.g. deforestation, trash pollution, occupation of territory for building). A location may lose its touristic appeal and therefore value, through over-tourism or over-use.
- Animals (e.g. destruction of habitats, expulsion of animals from their areas, food poisoning, changes to animal behavior, extinction of species).
- Exploitation of natural resources (the use of resources may be unsustainable).

Recreational activities such as diving, snorkeling, freediving, swimming, boat trips, etc. can damage coral reefs, marine animals and plants, if they are not carried out in a conscious and respectful way (Figure 36).

When tourism is not managed sustainably, it can ultimately damage the very places that make it possible. Through misuse or overuse, landscapes and natural environments may lose part of their value and attractiveness as destinations.

Figure 36 - Human disrespect toward coral.

Tourism can also affect local communities at a socio-cultural level. Rapid or poorly managed changes in the way communities live may contribute to the displacement of indigenous or local populations and to the erosion of local culture.

Environmentally responsible tourism is essential for the future of travel. It involves education, interest in local communities and their cultures, and respectful interaction with the environment. Choosing tour operators and businesses that follow sustainable practices is one way to support a more positive form of tourism.

Freedivers often travel to remote places where environmental protection and conservation may not yet be strongly supported by infrastructure, regulation, or local awareness. For this reason, they are encouraged to act as positive role models: collecting trash when appropriate, limiting the use of single-use plastics, avoiding the collection of anything from the Ocean, and interacting respectfully with local communities and ecosystems.

Value of diving locally

Finding dive sites closer to your home can help to reduce your CO_2 footprint. It also helps the development of local sites and tourism and reduces the strain on over-visited dive sites around the globe. Your local dive site may offer beautiful underwater landscapes and rich wildlife. Take the time to discover and appreciate it.

Eco-friendly travelling

The planning of your trip starts from the moment you pack, and there are many things you can consider for your trip.

These are ways that you can be more environmentally conscious and still enjoy travelling:

- Ways of travelling: when possible, walk or ride a bicycle. For longer distances, try to find car-pooling methods or public transportation (public buses, subway, trams and trains are more ecofriendly options than taking taxis or a short flight). When you cannot reach your destination via public transport, use low emission options such as small, hybrid or electric cars. If flying is the only option, try to fly less frequently and fly shorter distances. Try to bring your own food on board, avoiding the plastic wrapping of the in-flight meals. Choose flight companies that adopt carbon-offsetting to partially compensate for the impact of your travel.
- When travelling by plane, search for carbon-offsetting flights.
- Pack light. Lighter luggage helps reduce your carbon footprint: the lighter you travel, the less fuel is required, the lower the CO_2 emissions are.
- Refuse, reduce, reuse, recycle: the waste management in the destination country may not be ideal (non-existent, burning, burying, etc.). The best option is to avoid unnecessary packaging. Travel with your own cutlery, containers, bags, straws, water bottles (there are loads of travel size options). Refuse single-use plastic items.
- Pick up trash whenever you see it, especially when you encounter it in the water. Dispose it correctly. Get involved in local activities like underwater and beach clean-ups (check for local *Trash Heroes* groups or activities or create one yourself!).
- Refrain from buying souvenirs made from marine life. Limit your seafood consumption in restaurants and ensure the source is sustainable (not from illegal or destructive fishing methods).
- Buy local and seasonal: consuming local food, vegetables, fruits, clothing and souvenirs. Local products have a smaller CO_2 footprint than products that have travelled far to get to where you are. By choosing locally produced goods and services, you also support the community's economy.
- Make an effort to consume less electricity. Whenever you leave your room, turn off lights and air conditioning and unplug electronics.

- Give back to the environment: research organizations, foundations and projects that are involved in the protection of the local environment (volunteer, donate, share information).

10.4 Fishing

Overfishing

Overfishing is when fish are caught at a faster rate than they can reproduce. Currently, because of massive overfishing carried out for several decades, the ocean ecosystem and the fish stocks are in a state of decline worldwide.

The *United Nations Food and Agriculture Organization (FAO)*, estimates that:

- 80% of the world's fish stocks are fully exploited or overexploited (the fishery is being exploited above a level which is believed to be sustainable in the long term, with no potential room for further expansion and a high risk of stock depletion/collapse).
- 7% of fish stocks are depleted (exhaustion of the abundance of fish populations, catch amounts are well below historical levels, irrespective of the amount of fishing).
- 1% of fish stocks are recovering (catches that are increasing after having been depleted).

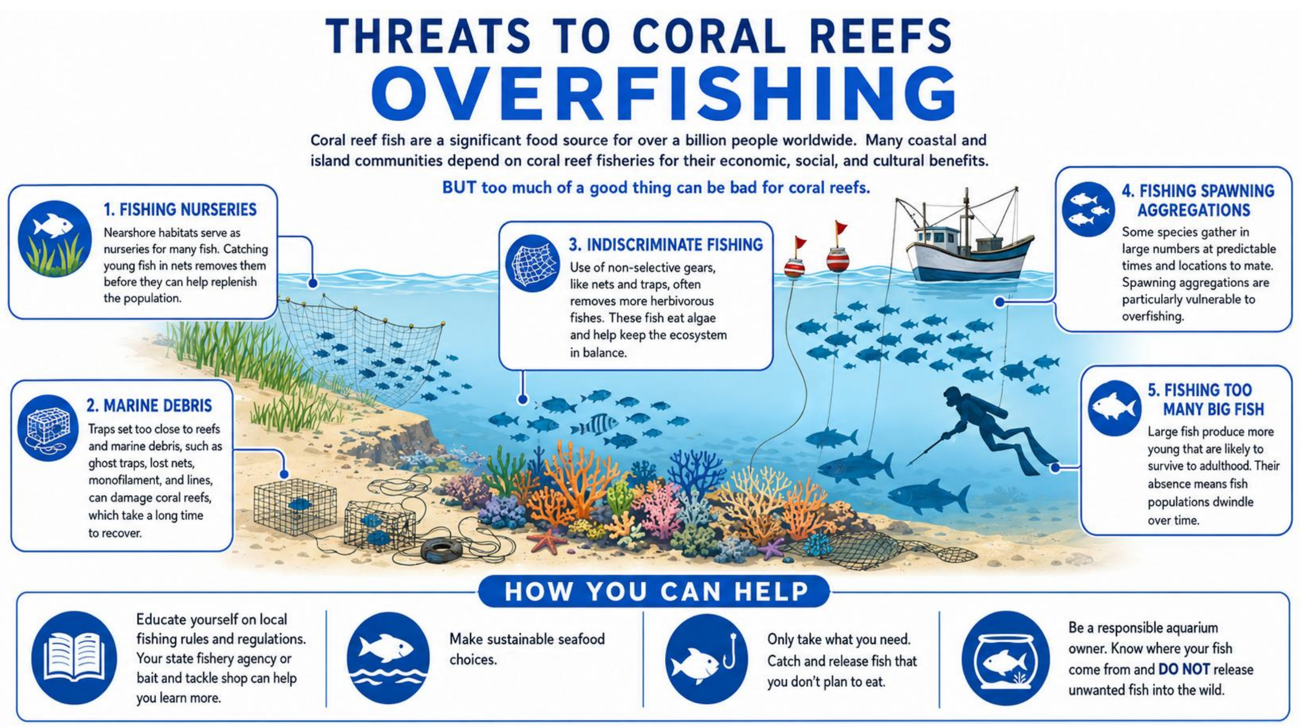


Figure 37 - Effect of overfishing on coral reefs.

Illegal fishing

Illegal fishing is when fishing activities do not follow local or international laws and regulations.

Sustainable fisheries

These are fisheries that take into consideration: the species, the season, the gender and the size of what is being caught so to reduce the impact of fishing and to avoid the depletion of the local fish stocks.

The health of the Ocean is increasingly fragile, and reducing fish consumption can be an important step toward lowering pressure on marine ecosystems. Sustainable wild-caught seafood does exist, but it is not always easy to identify or access. As conscious consumers, we have a responsibility to look for more sustainable options and to make informed choices whenever possible.

Responsible consumption also means paying attention to what is being sold or served. If you become aware that shark fin soup, cetaceans, or products from endangered or protected species are being offered in fish markets, supermarkets, or restaurants, report the activity to the relevant authorities when it is illegal to do so in that location.

Sustainability and legality

Legal fishing is not necessarily sustainable fishing. Some fishing practices may be legal and regulated, yet still place excessive pressure on fish populations and marine ecosystems. Commercial fishing is often shaped by financial interests, which do not always align with environmental protection. In many parts of the world, fishing regulations may be insufficient, poorly enforced, or based on incomplete scientific data. In other areas, effective rules may be lacking altogether. This is especially problematic where fish stocks have not been properly assessed through reliable scientific research.

The impact of unsustainable fishing

Unsustainable fishing on coral reefs leads to a reduction of reef species and harms the whole reef ecosystem (Figure 37). Destructive fishing methods cause physical damage to the coral reef, seagrass beds and marine habitats through. Fish themselves are core components of the reef ecosystems, and their removal compromises its delicate balance. Trade or commerce of endangered species leads often to the extinction of species. As the human population grows, the global demand for fish and seafood keeps increasing, leading most fish stocks towards complete depletion.

The use of more powerful fishing technology, inadequate management and lack of law enforcement is destroying marine species and their habitats.

Destructive fishing

Several fishing practices harm the marine environment, destroying habitats, bringing endangered species towards extinction and creating unbalances in the marine ecosystems.

- **Trawling**: it is the most common fishing method, and one of the most destructive ones. A trawling boat or ship drags or pulls fishing nets through the water, normally at seabed level. This kills and destroys anything in the path of the nets, including marine habitats, coral reefs and thousands of marine species living in the area. Despite its extreme harmful effects, it is legal and widely practiced in most parts of the world.

- **Long line fishing**: The use of lines with hundreds or thousands of hooks attached. These lines are generally submerged for many hours. This fishing method is destructive as it generates bycatch and causes the entanglement of many non-targeted species (sharks, turtles, dolphins, whales).

- **Bycatch**: This is not a fishing method per se, but a consequence of methods such as trawling, gillnets, longlines etc. Thousands of whales, dolphins, turtles, sharks, dugongs, seals and endangered species of fishes get caught and killed unintentionally every year while fishing other target species. Bycatch has no economic value, so it is commonly thrown overboard. It is estimated that 300,000 whales, dolphins and porpoises die every year from entanglement in fishing gear. Some estimates suggest that up to 40% of fish caught worldwide is bycatch. A great amount of bycatch is unobserved as it is caused by lost or abandoned fishing gear.

- **Ghost fishing**: Fishing gear that is lost or abandoned at sea (local or industrial fishing) is known as ghost nets (Figure 38). These abandoned and unused nets continue to trap fish and marine life, such as dolphins, turtles, sharks and whales. Ghost nets are estimated to form 46% of all ocean plastic.

- **Poison**: Sodium cyanide is poured into the water to stun fish without killing them. The fish float to the surface making them easy to catch. The major consequences are not only fish being poisoned; coral reefs and habitats are damaged, and the surrounding water is contaminated.

- **Explosives**: Dynamite fishing is used to kill fish in some parts of the world, so they float to the surface, making them easy to catch. Explosions destroy everything in the surrounding area, especially coral reefs.

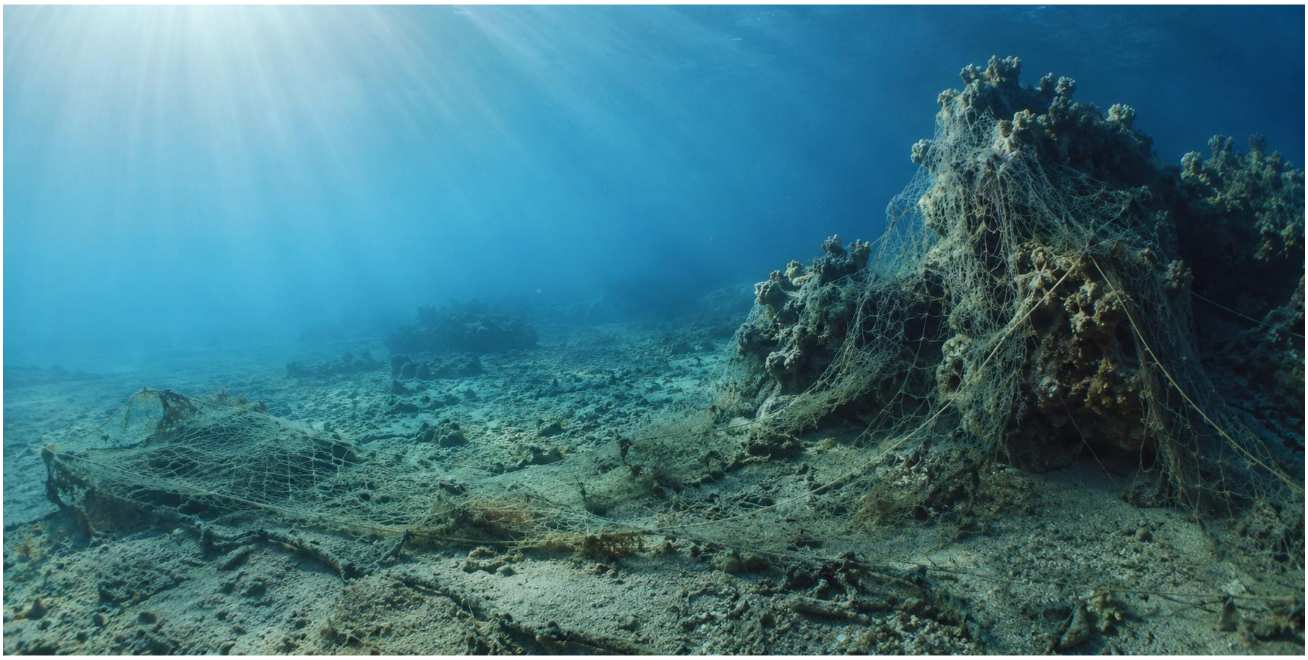


Figure 38 – Abandoned nets on the sea bottom.

Spearfishing

Spearfishing is generally considered a sustainable and selective method of fishing. However, there is a grey area in this assumption. When spearfishing becomes a popular recreational activity practiced by hundreds of people, it can lead to negative consequences on the environment. Even though the amount of fish caught is dramatically lower than industrial fishing, the fish targeted are often the largest and most productive of their species. Sometimes endangered species are caught, causing a quick decline in their numbers. In the Mediterranean Sea, especially along the Italian coastline, spearfishing caused the decimation of the grouper population and the disappearance from many habitats where they used to thrive. Only the implementation of *Marine Protected Areas* avoided the total extinction of a few species.

Big game fishing (catch and release as sport fishing) are creating wounds to the fish that could be fatal. Even brief periods out of the water, for example while a fish is being unhooked or photographed, can cause significant stress and may, in some cases, be fatal.

To ensure that you have fish to catch in the future and that the balance of the ecosystem is not compromised, please:

- Catch only what you need for your personal consumption.
- Avoid fishing in areas that are already overfished.
- Research which species, season and gender of the targeted fish are allowed to be fished, respecting the natural life cycle and reproduction patterns.
- Respect the quantity allowed at all times ("bag limit").

- Be aware of the minimum or maximum size limit for the target species.
- Do not catch endangered species. Research the endangered species in your area.
- Be respectful to what you kill. Avoid hunting for trophy pictures.
- Remember, the Ocean is already overfished. Shooting pictures of fishes can be more rewarding that shooting fishes, and it is far less destructive and more sustainable.

Figure 39 - Spearfishing.

It is important to increase our awareness of the impact of fishing. Catching and consuming one particular species affects the balance of the whole ecosystem. Many species play a fundamental role in preserving the balance of the ecosystems in which they live. Large predators such as tuna, sharks, giant trevallies and giant groupers hunt small predators, controlling their number. If large predators are removed from the ocean, the small predators quickly increase in number, decimating their prey, most of which are herbivorous fishes. The latter ones have a fundamental role in controlling the growth of algae in all marine ecosystems, so if they are hunted more intensively than normal, their numerical reduction cause algae overgrowth on corals and other reef building organisms, leading to the decay or disappearance of coral reefs and other delicate ecosystems.

How you can help:

- Inform yourself of local fishing rules and regulations.
- Make sustainable seafood choices (www.globalfishingwatch.org).
- Only take what you need, consider the species, season and size of the fish.
- Be a role model, minimize your impact and share your awareness with other freedivers.
- Report any illegal activity.
- Observe the changes in the marine environment and provide a positive contribution to its preservation.

10.5 Marine life interaction

Your way of interacting with marine life is critical for both its safety as well as yours. The recommended guidelines to follow whenever you are underwater are:

- Do not stand, touch or ride marine life: marine animals are wild and they do not enjoy being petted. You can easily injure them and yourself by stimulating a reaction from the animal.
- Do not chase marine animals: Going after an animal generates stress and increases the risk of injuries to the animal and yourself. Be a cautious observant and keep your distance.
- Do not stand on the seabed: Animals and plants live on the seafloor (e.g. seagrass, stingrays, flounders, crustaceans and sea worms). Be careful not to stir up sand (especially close to reefs or seagrass beds) or disturb animals with your long fins.
- Do not touch, step on or take corals: they are fragile living organisms, an intentional or accidental touch can destroy hundreds of years of growth. Mind your fins while freediving or snorkeling close to corals.
- Some coral is poisonous and can harm you. Animals hidden inside the coral can also be harmed through your touch, and they can also harm you.
- Do not feed marine life: Human food is not adequate for animals and can lead to intoxication of the animal and the environment. Another serious consequence of feeding marine animals is the disruption of feeding cycles and changes in behavior, leading to sickness or death and causing an imbalance in the marine ecosystem. The risk of feeding animals underwater is high on humans as well, especially when potentially aggressive animals may be present (e.g. Barracuda or Shark).
- Do not leave trace: do not abandon any litter into the ocean. If you see any garbage around, try to take it and dispose of it properly later when on land. Having a bag/net with you, or on your buoy will help you collect as much trash as possible (be careful with sharp objects).
- Do not remove seashells from the ocean or beach: Even though seashells are small, their removal has important consequences. When seashells are collected, beach erosion is increased and the abundance of calcium carbonate from recycled shells decreases, creating

imbalances in the oceanic carbon cycle. Many animals depend on shells for food and shelter (crabs, small fish, algae, seagrass): their removal can reduce the biodiversity of an area.

10.6 Role model through awareness

The Ocean sustains life on Earth, and humans must live in more sustainable ways to help preserve it. Its protection is a shared responsibility. Both individual and collective action are needed to manage Ocean resources responsibly, for the benefit of people, animals, and all living beings.

Protecting the Ocean also means recognizing our role in preventing further damage. By becoming aware of the problems and avoiding behaviors that contribute to them, we can be part of the solution and make our daily choices more environmentally responsible.

- Be mindful of your plastic consumption. Follow the "R's" rule: **refuse, reduce, reuse and recycle**.
- Avoid activities that require the burning of fossil fuels as much as possible.
- Use environmentally friendly methods of transport (public transport, carbon offsetting) where possible.
- Eat locally and seasonally. Reduce your consumption of meat, fish, dairy and any other animal product; choose plant-based alternatives.
- Reduce water pollution and runoff at home: when rinsing your freediving equipment, use a tank or bucket. If possible, rinse your gear while taking a shower (no longer than 2-3 minutes).
- Use coral reef friendly sunscreen (titanium dioxide or non-nano zinc oxide). Use clothing/hats instead of sunscreens whenever it is possible.
- Think about what you add into the environment when donning your suit with soap or lubricant. Verify that the soap or lubricants you are using are biodegradable. Keep soap out of the ocean: the best solution is to put on your wetsuit directly in the sea or under the shower.
- For your diving equipment (wetsuit, rash guards etc.) choose brands that have environmentally friendly products and ask your favorite brand or sponsor to become as eco-friendly as possible. Avoid plastic wrappings or minimize them as much as possible.
- Be a wise and responsible consumer. Maintain your gear in good condition so to extend its life span and try to repair items before buying new ones. You can also buy second-hand. Ask yourself if a new item is necessary or not.
- Most freediving wetsuits are made of neoprene, a synthetic rubber whose production has a significant environmental footprint. As freedivers, we should acknowledge that even essential equipment can have an impact on the environment. For this reason, choose wetsuits carefully, prioritize durability and proper fit, take good care of them, and repair them whenever possible instead of replacing them too early. When a wetsuit can no longer be used, do not simply throw it away: look for local wetsuit recycling, reuse or upcycling programs, or

ask the manufacturer, shop or diving community whether they collect old neoprene. Encouraging wetsuit recycling helps reduce waste and sends a clear message to brands that freedivers care about the full life cycle of their equipment.

- Choose wetsuits carefully, prioritize durable products, maintain them properly and repair them whenever possible. When a wetsuit can no longer be used, avoid throwing it away with general waste. Look for wetsuit recycling, reuse or upcycling programs, or ask manufacturers, shops and local diving communities whether they collect old neoprene.
- As AIDA freedivers, we can help reduce waste by extending the life of our equipment and encouraging brands to take responsibility for the materials they produce.
- Consume less, consume better. Be mindful of what and how much you consume in your everyday life.
- Choose ecotourism destinations, support environmental conservation projects and promote the establishment of Marine Protected Areas.
- Promote the use of renewable energy sources, support political decisions that promote them.
- Make every dive a clean-up dive (Figure 40).

10.7 Be an ambassador of the Ocean

Do whatever is in your possibilities to protect the Ocean. Share your knowledge and awareness with others.

Figure 40 - A freediver collecting plastic trash in the water.

Chapter 10 - Knowledge review

Why is there so much plastic in the ocean?

Explain the negative consequences of mass tourism in the following areas: beaches, cliff-sides, degradation of the landscape, animals, exploitation of natural resources.

Describe some ways to make travelling eco-friendly.

What is overfishing?

Name some of the impacts of unsustainable fishing.

Name some things to consider if you want to spearfish.

Name guidelines for marine life interaction.

CHAPTER 11

11 FREEDIVER CODE OF CONDUCT

Respect the environment

Respect marine life

Do not remove anything from the sea

Do not leave anything in the sea

Respect yourself, be responsible

Dive safe and be a role model

APPENDIX A

KNOWLEDGE REVIEW – ANSWERS

CHAPTER 2 - PHYSIOLOGY

Q: What is the function of blood in the human body?

A: Transportation of gases, nutrients, waste products, hormones and body heat; Protection from inflammation; Regulation of blood acidity (pH), and water balance by transferring water to and from tissues in the body.

Q: What is cyanosis and why should you warn your buddy about it?

A: As the skin is thinnest on the lips, a change in blood color due to a decreasing level of oxygen can be easily spotted ("blue lips"). However, this may also indicate that the freediver is hypothermic. In both cases, it is important to warn your buddy, as they may not perceive it.

Q: Define diffusion.

A: Diffusion is the natural tendency of a gas to move from an area of high concentration to an area of low concentration.

Q: Define veins, arteries and the particular case of the lungs circulation.

A: Veins are blood vessels carrying exhausted blood towards the heart. Arteries are blood vessels carrying fresh blood from the heart to the organs. The pulmonary artery carries blood low on O_2 from the heart to the lungs, while the pulmonary vein is carrying oxygenated blood from the lungs to the heart.

Q: Hyperventilating does not change the level of oxygen saturation in the blood, but it decreases its content of CO_2. True or False?

A: True.

CHAPTER 3 - THE MAMMALIAN DIVE RESPONSE

Q: What is the mammalian dive response (MDR)?

A: The MDR is a combination of several stimuli triggering a series of reactions that will allow you to conserve oxygen, to use it more efficiently, while also protecting your lungs from barotrauma in deep dives.

Q: Why is the blood shift vital for deep freediving?

A: When a freediver dives below residual volume (RV), the lungs can still be further compressed because of the blood shift: the blood vessels of the alveoli take up more blood.

CHAPTER 4 - LUNGS AT DEPTH

Q: What is the residual volume?

A: The residual volume (RV) is the amount of air remaining in your lungs after a maximum exhalation. On average it is 25% of the total lung capacity (TLC).

Q: What are the most efficient ways of increasing the vital capacity?

A: First, practicing proper "one full breath" technique (two-stage inhalation, see AIDA2) will allow you to fill your lungs completely. Second, practice diaphragm stretching will reduce the residual volume and thus increase vital capacity.

Q: What is the failure depth?

A: Failure depth is the depth where residual volume (RV) is reached, and normal equalization will not work anymore.

Q: There are several symptoms that indicate a lung injury upon surfacing after a dive. Name at least two of them.

A: You may feel persistent tightness in the chest that does not resolve after the dive. Your airways may be partially obstructed, causing a wheezing sound when breathing. Even after several breaths at the surface, you may still feel short of breath or unable to breathe normally. You may also feel the urge to cough in order to clear your airways; if you do, you may cough up pink, foamy fluid. Finally, you may experience persistent fatigue that does not go away.

Q: Advice that helps avoid lung squeeze.

A: Dive with self-awareness, dive relaxed or do not dive, do not dive if you are shivering, stretch your intercostal muscles and diaphragm, apply correct turns at depth, adapt slowly to depth.

CHAPTER 5 - BUOYANCY

Q: Being "too heavy" is obviously dangerous but being "too light" does not always means to be safe in freediving. Please comment.

A: Being too light you might overexert yourself on the first half of your dive, wasting energy in an attempt to overcome an excessive positive buoyancy.

Q: Explain and comment: "Setting your neutral buoyancy shallower should not replace good technique."

A: Setting neutral buoyancy too shallow means to dive overweighted, which can mask technical deficiencies. However, this is not a safe way to descend. If you have a hard time starting your dove you should work on your duck dive technique instead. Adding too much weight on your belt to make the descent easier can be irresponsible and dangerous.

Q: If you fall off-balance during freefall, what are your main means to correct that?
A: Head position in body axis, straight body posture, even weight distribution on the belt, correct speed, relaxation of body parts, gliding along the line with one hand.

CHAPTER 6 - EQUALIZATION

Q: There is a difference between the sensation of pressure-change and pain. Please comment.
A: Feeling pressure is essential for an efficient equalization technique, as long as it is a gentle sensation. Experiencing pain while diving is always an alarm signal upon which you should stop your descent immediately.

Q: Why is it not recommended to flush the sinuses with sea water?
A: Sea water is far from a sterile physiological solution. It contains pollutants and microorganisms that can cause infections.

Q: Regardless of what equalization technique you are using, what should be the main focus?
A: O*nly use the muscles involved in equalization and relax all others. Tensing the neck, jaw or belly are common mistakes that can lead to failure of equalization.*

CHAPTER 7 - BAROTRAUMA

Q: How do you prevent barotrauma?
A: You can prevent barotrauma ("squeeze") by eliminating any pressure differences acting on tissues or organs by equalizing the changing pressure. If a barotrauma occurs, remember these 4 words: "Stay dry, see doctor".

Q: What are the symptoms of eardrum perforation?
A: Sharp pain, vertigo and loss of direction.

Q: How does a middle ear barotrauma occur?
A: If you fail to equalize and do not stop your descend, blood and other fluids might be forced into the middle ear, partially or even completely filling it.

Q: Why is suspected middle ear barotrauma to be taken seriously and always checked by a doctor?
A: The fluid in your middle ear is a great risk of infection for your ear.

Q: Why should you avoid equalizing if you are experiencing a reverse block?
A: Equalization pushes more air into your sinus, but in a reverse block there is already too much air in the sinus and/or middle ear. Ascend as slowly as you can, using the rope as a guide in case you should suffer from vertigo. The trapped air will eventually get released.

Q: What is alternobaric vertigo?

A: Alternobaric vertigo (AV) is commonly occurring on ascent when one ear depressurizes slower (or incompletely) compared to the other. The difference in middle ear pressure can cause the brain to falsely interpret this as bodily movement. Involuntary eye movement, nausea, vomiting, tinnitus and muffled hearing can be symptoms of AV.

Q: A well-fitting hood can be a problem when it comes to hood squeeze. Explain.

A: If the hood seals off very well (which a well fitted hood doe!), air that might be trapped in the ear canal between the hood and the ear drum will get compressed on descent and might cause injury to the ear drum or the ear canal.

Q: How should you do when experiencing a blocked sinus on descent to avoid a sinus squeeze?

A: If you experience a sinus block, stop your descent immediately by holding onto the diving line: relax and equalize again. If the pain does not go away, you will have to abort the dive and ascent carefully.

Q: What is the best advice to avoid a sinus block?

A: Do not dive with a cold or congestion; hydrate.

CHAPTER 8 - HYPOXIA AND BLACKOUT

Q: Why is there no benefit in blacking out?

A: It is a stressful event, and that the brain will adapt to work under low oxygen circumstances by repeatedly inducing blackouts.

Q: Give examples of how cerebral ischemia can occur

A: Low blood pressure; getting up too quickly; hyperventilation leading to cerebral vasoconstriction; tight hood in the neck area; air pocket under the suit; external pressure on the neck.

Q: What is the meaning of the term shallow water blackout in freediving?

A: It means loss of consciousness caused by hypoxia towards the end of a freedive. Hypoxia is caused or heightened by the changing water pressure when coming up from a freedive.

Q: Decompression illness occurred only to divers that breathe compressed air, such as in scuba. True or false? Comment.

A: False. Decompression illness (DCI) can also affect freedivers, in case of very deep/long dives as well as repeated dives with not enough recovery time in-between.

CHAPTER 9 - TRAINING CONCEPTS

Q: What is the “save the legs” approach?

A: One of the limiting factors in constant weight freediving is the lactate tolerance of leg muscles towards the end of a dive (“heavy legs”). Therefore, warm-up dives should be performed with the least possible physical effort on these muscles, so that they will be fresher during the actual dive.

Q: What is the rationale of a CO_2 table?

A: A CO_2 table is constructed so that the CO_2 level in your body increases with each breath-hold. The table allows you enough time between breath-holds to re-establish a good level of O_2 in your body, but not enough time to fully offload excess CO_2. The purpose of these tables is to train and increase the tolerance to CO_2 both physically and mentally.

CHAPTER 10 - AIDA GREEN: FREEDIVERS FOR THE ENVIRONMENT

Q: Why is there so much plastic in the ocean?

A: The overuse of plastic is partly driven by our enormous consumption of plastic products, as well as by the lack of pressure on industries and governments to develop and adopt better alternatives. Without clear expectations from society and the global community, companies and governments may feel little responsibility for the environmental consequences of their material choices. In many parts of the world, there is also inadequate infrastructure for collecting, sorting, recycling, or safely disposing of plastic waste. Even where disposal facilities exist, littering and improper disposal further contribute to existing environmental problems.

Q: Explain the negative consequences of mass tourism in the following areas:

A:

- ***Beaches**: pollution, damage to coral reefs, disturbance to marine life.*
- ***Cliff-sides**: over construction and trash.*
- ***Degradation of the landscape**: deforestation, trash pollution, occupation of territory for building.*
- ***Animals**: destruction of habitats, expulsion of animals from their natural habitat, changes in animal behavior, extinction of species.*
- ***Exploitation of natural resources**: The usage of resources happens in a non-sustainable way.*

Q: Name some strategies to make travelling eco-friendly:

A:

- *Pack light.*
- *Ways of travelling: public transportation, low emission transportation, bicycle, flying less frequently. Watch out for the carbon dioxide emissions footprint.*
- *Refuse, reduce, reuse, recycle.*
- *Pick up trash.*
- *Do not buy souvenirs from marine life.*
- *Eat in restaurants with sustainable food sources.*
- *Buy local and seasonal.*
- *Reduce electricity usage.*
- *Get involved in marine conservation activities and support organizations and projects that take care of the ocean.*

Q: What is overfishing?

A: Overfishing is the action of catching fish faster than they can reproduce, i.e. not allowing the fish stock to recover and grow in a healthy cycle.

Q: Name some of the impacts of unsustainable fishing:

A:

- *Physical damage to coral reefs.*
- *Reduction of fish stocks.*
- *Destruction of seagrass beds.*
- *Extinction of marine species.*
- *The catching and trading of endangered species.*

Q: What are the things to consider if you want to spearfish?

A:

- *Catch only what you need and never more than you can eat.*
- *Catch the correct species and gender.*
- *Respect the maximum quantity that you can legally catch within the season.*
- *Do not catch endangered species.*
- *Be aware of the minimum or maximum size that the species needs to be to make a catch sustainable.*
- *Be respectful to what you kill. Avoid hunting for trophy pictures.*

Q: Name some of the guidelines for marine life interaction:

A:

- *Do not stand, touch or ride on marine life.*
- *Do not stand on the seafloor.*
- *Do not touch, step on or take corals.*
- *Do not feed marine life.*
- *Do not chase marine animals.*
- *Do not litter or leave garbage in the water - pick up litter and put it in the bin when back on land.*
- *Do not remove seashells from the ocean or beach.*

If you notice any errors, inconsistencies, or have suggestions for improvement, we encourage you to share your feedback with us at support@aidainternational.org. Your input helps us continuously improve the quality and consistency of AIDA materials.

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