UNDERWATER COMMUNICATION

Skills for a new way of diving

OCEANREEF®
connecting divers

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Chapters

Communications as the essential medium for the development of society, advances in safety, and greater interaction among people

The biggest achievement of the last 50 years that has had the greatest effect on our daily lives wasn't man landing on the moon (despite its incredible importance), but the invention and development of the cell phone.

The life of the entire planet changed when the use of cell phones began to spread in the late '80s. Today, there are countries that have more operational cell phones than people.

The internet has also had an equally jarring effect on our everyday lives. With regards to the realm of the internet, special mention must be made of the phenomenon of social networks, which show the extraordinary human search for communications and interaction.

In every phase of human history, communications have made a powerful impression; without communications, no civilization would have been able to develop, nor would any of them have been able to achieve predominance. Those who are able to control energy and communications have always had an advantage over others.

On the other hand, without an efficient communications network, information does not circulate, or it moves too slowly, and the entire system gets clogged or moves forward only at a crawl; work, finance, entertainment, safety... everything depends on the quality and power of the communications network.
The introduction of cell phones into our lives has been very beneficial in many ways. With safety being a concern in today's day and age, even children are carrying some form of communication.

As in all things, communications have at times reached situations of excess. The reaction is to flee, searching for the peace that is often denied to us by the pace the contemporary world has reached. As always, it's a question of education and the proper approach. The mere availability of means should not lead us to use them poorly or improperly. This too is yet another distinctive sign of our times, in which extremes are sometimes increasingly focused upon.

The world of diving explores many different directions, from recreational free-diving, to spearfishing, to diving with respirators to admire the underwater world, take photographs, or conduct one's profession.

One of the most classic representations of the underwater world (in so many famous movies) is to call it **THE WORLD OF SILENCE**, and to enjoy this special state in which certain senses are cut off, favoring sight and concentrating on colors and often on spectacular landscapes.

Nonetheless, capitalizing on this opportunity does not require you to forgo the objective advantages that modern technology can put at our disposal. A cell phone can easily be turned off if we don't want to be called or disturbed, but it's very convenient to have it available at all those times when, for pleasure or necessity, it's vital to communicate with those around us.

In this book, we'll try to explain what diving communication is, how it works, and how it can be used. We will be discussing how to get the best performance out of today's technology and how communications can be fully integrated into the many activities that are performed during dives for business, study, research, recreation, and even teaching.

Finally, and just briefly, we ask what any type of human pursuit or discovery might be without communications, and above all whether it would have been possible to achieve the levels we're accustomed to without the development of communications in every field.

We believe that an in-depth understanding of how to communicate underwater is a crucial step in the development, civil use, and protection of the oceans, as well as the safety and growth of dive professionals.

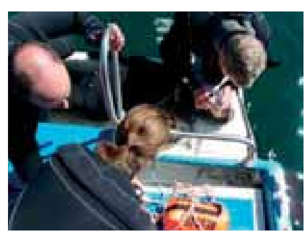
Communications in diving

Some divers insist on principle that the silence of the deep is one of the most appealing features of this sport, and that taking any form of communication on a dive is little short of blasphemy!

While we respect this attitude, which celebrates one aspect of the underwater world, we cannot deny that communications can sometimes have serious implications in terms of safety, research, teaching and simple human interaction that cannot be rejected altogether.

Additionally, communications are often essential! In some cases it can save a human life

People who work underwater must utilize communications with their colleagues and the surface for both logistical support and safety. The same is true for people whose business is teaching, education, or recreation. How many times have you found it necessary to inform your colleague or even your boat of what you were seeing, hearing, intending to do or not to do, or even simply to ask a question.



Some years ago two people set out on a dive to free a snagged fishing net. The divers became entangled. Unfortunately, no one on the surface realized what was happening before it was too late. The consequences were tragic. A way for the divers to communicate with the surface would probably have averted this tragic disaster.

Gallinara Island- Italy, summer 2009: two divers had an accident and were transferred urgently to dry land. The boat came to the aid of the injured divers and left the area, when the other divers resurfaced, they found no boat waiting. They weren't aware of what had happened and were left to their own devices. A communicator would have been useful to alert them to return, or at least to inform them of what had happened without running additional risks.

Lake Como, autumn 2009: Two divers were found lifeless after a lengthy search. No air remained in their tanks. The use of communications systems might have allowed them to be located faster, and might even have prevented the accident (they might have been able to warn someone of what was happening).

Summer 2008, an oversight with my pressure gauge, and my air ran out before my decompression stop was over. I called the surface and warned my dive buddy. They got a tank ready for me and my buddy was by my side for the quick ascent. An ugly experience, yet handled perfectly thanks to the use of communicators.

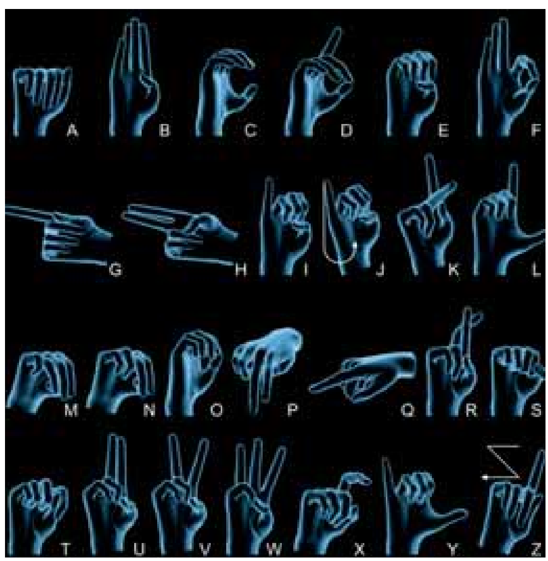
September 2007: diving with an English journalist. The weather changed suddenly, and a furious thunderstorm erupted. From the surface, they warned us to wait before coming back up. Getting back into the boat would be much harder under those conditions. Thanks to the communicators, we waited and returned to the surface when conditions were back to normal.

The list of cases exemplifying the vital use of underwater communicators stretches to infinity. Teaching underwater and describing the environment and the animals is an interaction we're used to on the surface, why not underwater as well? Conducting dives and classes with communications gives the ability to deliver the necessary instructions clearly and unambiguously instead of using gestures that can cause confusion or be misinterpreted.

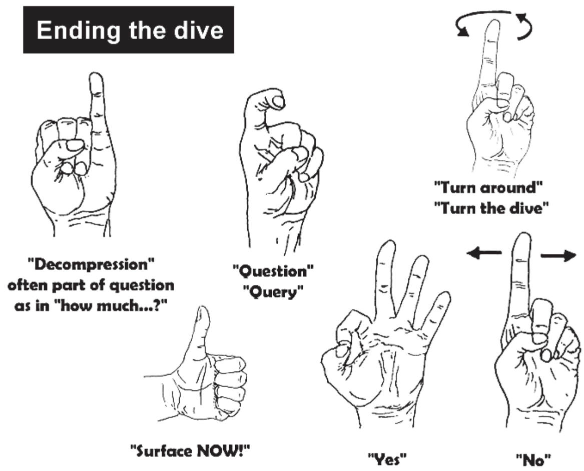
2a – **Sign language**

For decades, before the industrialized manufacture of full-face masks – which allow for comfortable speaking – and before the development of underwater communicators, visual forms of communications were developed that are similar to sign language.

Teaching organizations adopted an alphabet, assigning a meaning to specific certain gestures and creating a language that could be used while diving.



Here are a few examples.

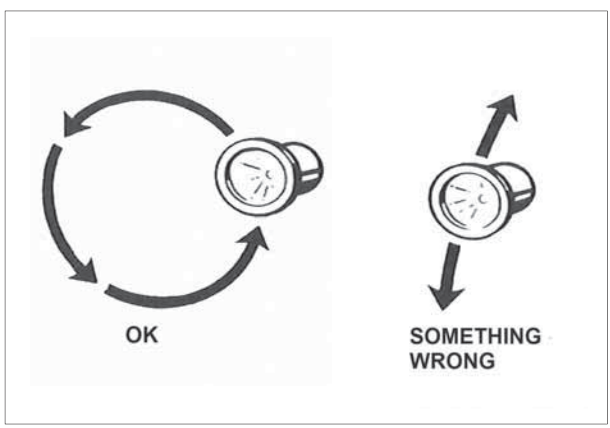


Sign language, despite the objective limitations vderiving from the requirement that it be used over short distances and facing the subject with whom you wish to communicate, has a certain importance that should not be underestimated. In fact, every system should have a backup, a solution to use when the primary system fails. This is a crucial principle in all activities in which error must be eliminated or limited to the greatest extent possible.
The use of radio or television as forms of complete communication does not eliminate alternative forms or our need to understand them. A good example is Morse code, which in its simplicity can be used visually, or as a frequency with audible tones, which can be incredibly useful.

Therefore the crucial recommendation is:
Understanding signaling forms of communications used by commercial organizations or training agencies is critical to achieving full mastery of communications methodologies. Imagine for example that for some reason your communicator is not functioning properly; you still need to make yourself understood to others.

2b - **Night diving signals**

During night dives, underwater torches are used to communicate. Naturally, a simplified language was adopted to indicate “Everything is OK” or instead if there are “Problems”! The use of these diving signals vhas been proven to be more manageable then using Morse code (which clearly isn't terribly practical during a dive). On the left are the signals provided in the PADI manual.



2c - **“Line-pull” communications**

“Line-pulls” is one of the oldest methods used to communicate between divers and surface. A diver descends pulling along a line from the boat that stretches through the water and is always kept gently taut. To communicate, either end uses a series of one, two, three or four tugs - agreed upon before the dive and depending on the dive itself - and in general a long tug means “I'm about to speak”, and an equal pull in response means “I'm listening”. It seems primitive, and it is, but it is still widely used by people working who only need to communicate occasionally.

2d - **Audible methods for simple communications**

Another form of communication that can be compared to sign language and Morse code is the use of so-called "bangers": basic acoustic signalers that generate audible noises underwater.

They are usually elastics with a rigid cylinder affixed to the tanks. Pulling on the elastic and then releasing it causes noises against the tank that propagate easily through the water. These audible acoustic signals can then be organized by the diving group to create a simplified language.

For example: one bang = everything's ok, 2 bangs = go back to the boat, etc.

Speaking underwater

Two things are required in order to speak underwater: a sufficiently large volume of air in front of the mouth, and the facial mobility needed to speak as we do on the surface.

This requires a full-face mask, or a half mask in front of the mouth to which the regulator is attached. The latter was the first affordable system offered. This mask was relatively inconvenient because of the precarious seal and the laces. It was also too small for good performance. Furthermore, it alters the performance of a conventional regulator, which is designed to be kept in your mouth and not a few centimeters away.

By wearing a full-face mask, you can communicate without a transceiver; simply speak inside the mask. The Neptune Space is facilitated by the rigid polycarbonate window that transmits sound well to the surrounding environment. Clearly, the operating distance is limited to a few meters, and is a function of the volume of the voice, but it is undoubtedly an efficient form of short-distance communication.

In the past, half masks were produced that could be connected to the regulator. These masks featured a metallic insert: a dot of copper alloy. This insert was meant to function as a "phonic membrane" that could transmit audio from inside to outside. This method is a very affordable solution, but one of little importance that never managed to take off because the communications distance was severely limited. Breathing was impaired and very uncomfortable.

The transmission of audible sound underwater is technically feasible, but contingent upon the elements we described above. Consequently, methods typical of communications on dry land were developed: cable, or wireless, with the latter using the transmission of ultrasound waves as the "carrier".

3a - **Hydrophones**

Forms of communication using hydrophones have also been attempted. Hydrophones are waterproof loudspeakers that use more or less elevated frequencies and full protection from the water to transmit sound waves in the audible band underwater. They are often used to broadcast music in the pool, and less frequently for classic dive communications.

They are also widely used in scientific research as a passive tool (listening for audible underwater communications among cetaceans), and an active one (sending audible signals). Additionally, hydrophones are used in fishing to attract specific types of fish depending on the frequency used.

The limited use of hydrophones for classic dive communications has not developed further because it requires considerable power to reach great distances.

Therefore, it is not easily compatible with portable individual systems and because of its powerful interaction with surrounding marine environment.

3b - **Communicating by cable**

Since the earliest days in the history of diving, there has always been talk of creating/maintaining a connection between a diver and the surface or among multiple divers. A powered console on the surface with a microphone and speaker, a cable that reaches the diver connected to a microphone and speaker installed inside and above the helmet or full-face mask. These are hardwired communicators.

Hardwired communications include a powered console on the surface with a microphone and speaker, a cable that reaches the diver connected to a microphone and speaker installed inside and above the helmet or full-face mask.

Wired connections are certainly the simplest (they re-create underwater the concept of an intercom or a wired telephone) and in some ways also have the best audio qualities.

Obviously, their use is limited by the requirement for dozens or hundreds of

meters of cable, which is often difficult to manage and restrict the diver's movements

However, this method does make possible the telephonic type of communication known as "full duplex”. Full duplex means that you can speak and listen at the same time, while "half duplex" (as in walkie-talkies) allows users only to speak or listen, but not simultaneously. The user must press a button to transmit, and release the same button to listen (a well-known operation in the use of terrestrial radio transmitters). Underwater communication systems using cables are very widespread, and are used especially in the commercial/industrial sector where it is often necessary for the diver to remain ALWAYS connected to the surface with an umbilical cord. For this reason, communication cables are often furnished with stranding around the electrical cables that increase the resistance to tensile stress. This cable becomes a part of the recovery line which is firmly connected to the diver's body, and which can be used to bring the operator back to the surface should it become necessary.

3c - **Laryngophone**

The laryngophone is a type of ***microphone*** that captures sound in contact with the neck. Contact capture eliminates or at least reduces environmental noise, where other microphones would not work well because the voice would be overpowered by background noise. This type of microphone can even capture whispers, and works well in environments where people need to remain silent while communicating with others over long distances, such as during a covert military operation. Laryngophones were used intensively in airplanes during the Second World War, and by crews in German ***tanks***. New single-element designs are available that make the laryngophone much more comfortable to wear than older models. Additionally, this next generation of throat microphones provides varying outputs and frequency responses to accommodate a wide variety of communication devices such as digital and analog portable radios, Tetra & P25 systems, and cellular phones.In diving, they are very useful for amphibious operations in which most activity takes place on dry land. A user opting for a conventional mask over a full-face mask means accepting a reduction in quality. This is because of the difficulty in speaking with the regulator in your mouth. This also provides indisputable flexibility and comfort for activities on land. In any event, laryngophones require either a wired or wireless transmission system.

Ultrasound

The system with the most in its favor is undoubtedly ultrasound. A diving communicator can be small, compact, as light as a package of cigarettes, yet still guarantee a reasonable capacity and good quality.

Communicators that use ultrasound waves are generally classified as wireless devices.

Let's take a minute to understand the operating principles of ultrasound communications. We'll need to "dive" into the study of physics.

4a - **Radio waves and ultrasound–The principles of physics–Why radio waves are not used underwater**

Radio waves are a type of electromagnetic radiation with frequency ranging from zero to 300 GHz, meaning with a wavelength from 1 mm to infinity. But in order to understand the limitations on using it underwater, we must first understand what an electromagnetic wave is.

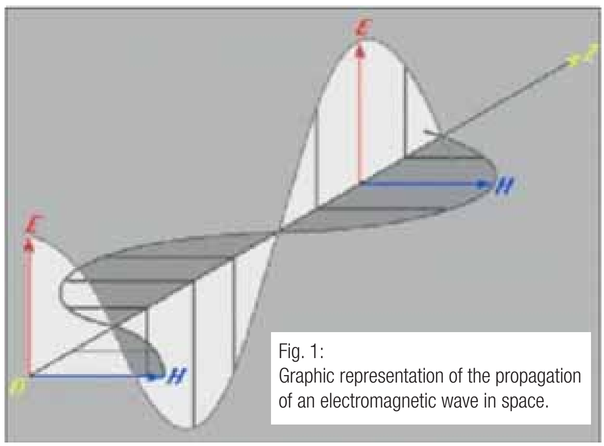


Fig. 1:
Graphic representation of the propagation of an electromagnetic wave in space.

Because of its charge, an immobile electron generates an electrical force in the space around it – **the electrical field** – that decreases inversely by the square of the distance from the charge.

Now, let's suppose we make that electron oscillate back and forth: the electrical field in the surrounding points is disturbed because of the changing distance from the electron during its oscillation. A change of electrical field generates a **magnetic field**. These oscillations in the electrical field — and therefore in the magnetic field as well — propagate from the electron, generating the **electromagnetic waves**.

A second electron at a certain distance from the first is still, but it begins to oscillate as soon as it is touched by electromagnetic wave produced by the first electron. The electrical field of the second electron is then also disturbed by its own oscillation. In turn, it generates a magnetic field. Thus, allowing the wave itself to **propagate**.

The size of a wave is its **amplitude.** It provides a measurement of the **intensity** of the electromagnetic wave. This, in turn, means the **energy** of the electromagnetic field carrying it.

Thus, radiation is composed of electromagnetic waves, consisting therefore of the concerted oscillation of an electrical field and a magnetic field. These waves propagate orthogonally to the direction of the oscillation.

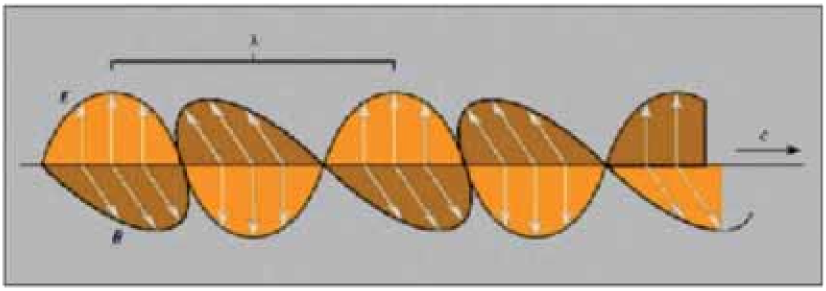


Fig.2: Graphic representation of the propagation of an electromagnetic wave over time

The amount of information that can be carried by a radio signal (see modulation) is proportional to its frequency, which explains why the minimal frequencies used in radio engineering to transmit voices begin at a few dozen KHz.

While this region of the electromagnetic spectrum is small compared to others (ultraviolet, infrared, X-rays, etc.), it is historically the most highly utilized for radio communications. This came about largely because low-frequency waves are easy to generate with the electrical devices within the reach of 19th century physics (oscillators, antennae, resonance detectors), and therefore available in the time of Heinrich Rudolf Hertz, Guglielmo Marconi, and Nikola Tesla. Another advantage of larger wavelengths is that they propagate through ionospheric reflection over intercontinental distances, which was clearly of interest in an age in which no radio bridges or telecommunications satellites existed

4b - **Bands**

The range of radio waves is conventionally divided into the following bands:

Band	Frequency	Wavelength	Main uses
	< 3 Hz	> 100,000 km	
ELF (Extremely low frequency)	3–30 Hz	100,000 km–10,000 km	Radio communication with submarines, tubing inspections, study of the terrestrial magnetic field
SLF (Super low frequency)	30–300 Hz	10,000 km–1,000 km	Communications with submarines, such as the Russian ZEVS radio
ULF (Ultra low frequency)	300–3000 Hz	1,000 km–100 km	Used for communications in mines
VLF (Very low frequency)	3–30 kHz	100 km–10 km	Navy, communication with emerging submarines
LF (Low frequency)	30–300 KHz	10 km–1 km	Intercontinental AM radio transmissions Transmission of the standard time signal for radio-controlled clocks
MF (Medium frequency)	300–3000 KHz	1 km–100 m	AM radio transmissions
HF (High frequency)	3–30 MHz	100 m–10 m (Short waves)	Ham radio operators, cell broadcast, intercontinental transmissions in Morse code
VHF (Very high frequency)	30–300 MHz	10 m–1 m	Commercial FM radio, aviation, marine, law enforcement, television, ham radio operators, radio beacons
UHF (Ultra high frequency)	300–3000 MHz	1 m–100 mm	Television, cellular telephony, WLAN
SHF (Super high frequency)	3–30 GHz	100 mm–10 mm	Radar, satellites, WLAN
EHF (Extremely high frequency)	30–300 GHz	10 mm–1 mm	Satellite and ham radio transmissions

The UHF band overlaps the radio wave and microwave areas; the boundary is indistinct.

The ELF, SLF, ULF, and VLF bands have frequencies equal to those of sound waves, but while the former are electromagnetic waves, the latter are mechanical vibrations of the air.

Ultralow frequencies are used for communications with submarines ***because the water attenuates the electromagnetic waves proportionally to frequency, with a high coefficient.***

Only very low frequencies can propagate over hundreds of kilometers, but they require enormous antennae consisting of sunken wires covering several dozen kilometers. Only a very small amount of information can be conveyed with these waves: messages parceled out slowly, and certainly not a voice.

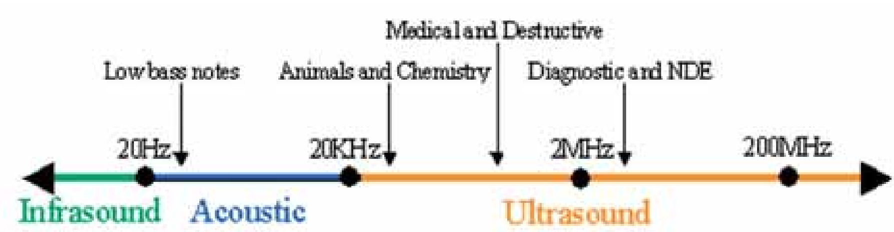
Therefore, in order to achieve sufficient range, it would be necessary to work with incredibly long antennae (impractical on the individual level) and considerable levels of power. In any case, because of its low frequency, a radio wave would be unable to convey a sufficient amount of information to sustain an audio conversation.

Water is highly electro-conductive (and saltwater in particular). This means that a radio wave has incredible difficulty propagating in such a conductive environment.

Ultrasound waves on the other hand, are mechanical sound waves. Their speed and propagation are therefore affected by the element in which they travel.

Differently from acoustic phenomena properly speaking, the frequencies that characterize ultrasound waves are superior to those generally audible to the human ear. The frequency conventionally used to distinguish between sound waves and ultrasound waves is 20 kHz. The very term itself - "ultrasound" - clearly indicates that it is beyond (ultra) sound, identifying only audible physical phenomena as sound.

Like every other type of wave phenomenon, ultrasound waves are subject to



reflection, refraction, and diffraction phenomena. They can be defined using parameters such as frequency, wavelength, propagation speed, intensity (measured in decibels), and attenuation (due to the acoustic impedance of the medium traversed).

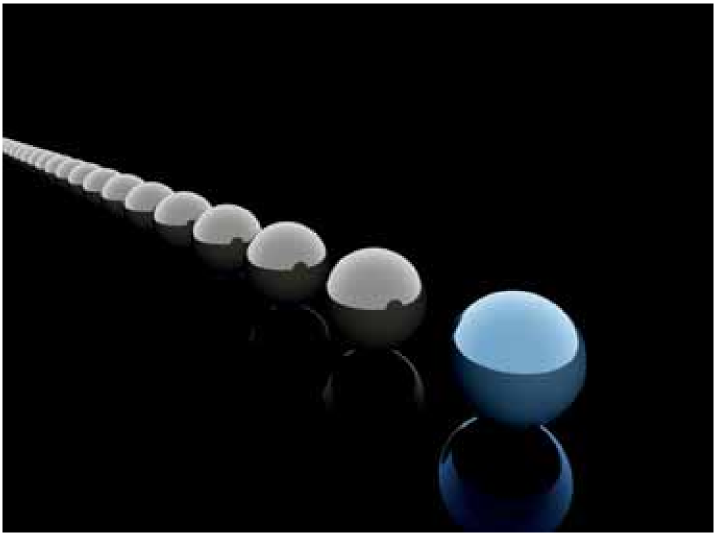
4c - **Generating ultrasound waves**

Ultrasound waves are generated using materials with special mechanical and electrical characteristics ***known as piezoelectric*** materials.

These special materials, such as quartz or barium titanate, have the characteristic such as generating a potential difference if compressed or stretched transversely; conversely, If a potential difference is applied to their ends, they compress or expand transversely. It is this latter characteristic that is exploited to generate these mechanical waves beyond the audible range (ultrasound). Therefore, based on the material selected, different frequencies of ultrasound waves are achieved, they propagate differently through materials, and the generating machines have different power characteristics.

The physical phenomenon of piezoelectricity or magnetostriction that was used to generate the wave is reversible. It follows that the same crystal capable of emitting ultrasound waves can also generate an electrical or magnetic signal, when it collides with a band of elastic waves. Therefore, when the wave reflected or emitted by the obstacle returns to the probe that generated it, it will issue an electrical signal that, when properly amplified and filtered, can be visualized on the display of an oscilloscope or a monitor, which ultrasound detection devices always feature.

Propagation of sound



We've said that sound propagates in elastic media, and clearly these media include air and water. To understand how this occurs in practice, let's look at the structure of air. Air is made of many molecules linked together by elastic bonds. We can imagine air molecules as something like spheres joined to other spheres by springs. When a body vibrates, it communicates its movement to the first air molecule (the first sphere in the model). As it moves forward, this molecule "pushes" the next molecule, which in turn "pushes" the next, and so on. A moment later, the elastic bonds (the springs in our model) "pull" the molecule back toward its original position of equilibrium. Because of the force of inertia, the molecule moves past its central point of equilibrium, reaching a distance nearly as far from the center as it traveled in its largest trip forward. These movements are transmitted to the contiguous molecules in a certain period. The effect of these movements is to create areas in which the air is compressed, and others in which it is rarefied. These different areas repeat starting from the source, in the direction of the propagation of sound. This effect is called l**ongitudinal wave.**

A wave is called longitudinal when the direction of oscillation and the direction of propagation coincide.

Given a source of sound, it propagates in all directions in the same way. We can say that it propagates according to spherical wave fronts. The surface of the wave front increases in proportion to the square of the distance from the source. Consequently, the energy that the wave front possesses is distributed across its entire surface, and therefore on a single unit of surface we have a quantity of energy that decreases proportionally to the square of the distance. Because the energy is proportional to the intensity of the sound, we can say that:

Sound intensity decreases with the square of the distance.

We can see then how the factor of distance is very important in the constriction of acoustic intensity.

Sound propagates at a speed that depends on the nature of the elastic media in which it spreads. In addition, this speed is influenced – albeit to a lesser degree – by temperature, pressure, and humidity. Let's see what the speed of sound is in various elastic media (in meters/second):

Carbon dioxide	258 m/sec
Oxygen	317
Air	340
Water	1,437
Copper	3,560
Marble	3,810
Iron	5,000

The propagation speed, in relative terms, can be represented by the formula below:

V= ð/T
Where ð= the density of the water and T is the temperature.

Therefore, sound will have greater speed (propagation) in a dense environment at low temperatures.

In particular, in water it will travel 4.5 times faster than it does in the air. If the water is salty, this proportion rises even further.

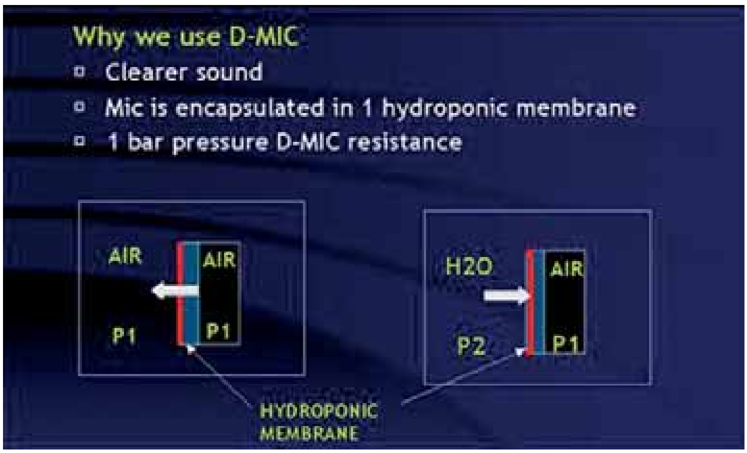
Sound that spreads through areas with differing densities or temperatures is reflected and refracted. Therefore, the progressive drop in power equal to the square of the distance will be joined by an additional filter factor.

In addition to losing strength as it moves away from the source, it will also be further constricted every time the density and temperature changes (rocks, algae, fish, wrecks, dissolved air, etc.) and the temperature changes. In particular, stark discontinuities (thermo clines, abrupt changes in the density of a material) cause very significant drops in the ultrasound signal.

Refraction is the deviation undergone by a wave that occurs when it passes from one media to another in which its ***propagation speed changes***. The refraction of light is the most commonly observed example, but any type of wave can be refracted: for example, when sound waves move from one media to another.

5a - **The D-Mic microphone**

The D-Mic is a dynamic microphone with hydrophonic protection. A membrane that is impermeable to water but PERMEABLE to air allows for maximum sensitivity to sound yet still protects the delicate electromagnetic components. The hydrophonic membrane allows the pressure to balance between the inside of the microphone and the mask, which in turn maintains the pressure of the outside environment thanks to the incorporated regulator. This balance between pressures makes it so that even if the mask is removed underwater, the microphone is still insulated from the water.



But what happens if the diver removes the mask and starts back toward the surface (a possibility perhaps when practicing ascending without your mask) or the mic goes back down (unlikely, but it's always possible that your dive equipment could be sent to depth again for some reason).
In the first scenario, if an ascent speed of 10 meters/minute is maintained, the air expands inside the microphone and filters through the hydrophonic membrane. If the ascent speed is excessive, the expansion of air will cause the membrane to flex outward and eventually rupture, flooding the microphone.

In the second case, the membrane will flex inward because it is impermeable to water. It will withstand the pressure to a maximum of -10 meters, at which point it will burst, with the same consequences as the previous case. At this point the microphone cannot be repaired and must be replaced, however, no damage was caused to the electronics of the communicator.

How to communicate effectively underwater

6a - **Before diving**

The set of equipment that allows a diver to communicate with other divers or with the surface is called a ***communications network***.

It may be composed of:

- **An underwater transceiver unit called a SUB T (or more than one: SUB T1, SUB T2, etc.)**
- **An underwater receiver unit called a SUB R (or more than one: SUB R1, SUB R2, etc.)**
- **A surface transceiver unit called SURF.**

Before diving, users should check that each unit is correctly switched on, following the unit's directions. If the units do not turn on, the battery or other power source should be checked and replaced if necessary. For wireless underwater units, it's important to keep the following on hand:

- **Replacement batteries**
- **Silicone grease to lubricate the O-rings**
- **Phillips screwdriver for removing and refitting the battery compartment cover. ,**

For surface units, the charge in the rechargeable internal batteries should be checked (in models M105, M105 DC, ALPHA PRO X Divers, Gamma 105, and Gamma ALPHA the charge is shown on a LED scale on the panel).

For wireless SUB T and SUB R units, these checks must be conducted BEFORE entering the water.

1. The battery compartment must be closed and have no defects on the outside.

2. Power on test: Wet two fingers and short-circuit the two wet contacts on the case. You should hear a beep. The unit turns on. If not, check the battery and replace if necessary.

3. Transmission test (1): Keeping your wet fingers on the contact, press the PPT button. You will hear a loud monotone signal lasting approximately 1 second: this means that the unit is on and transmitting.

4. Transmission test (2), with the help of a buddy: hold two units near each other (a few centimeters apart), with both turned on as described in step 2. Press the SUB T1 button and say a few words into the microphone. You should hear your voice through the SUB T2 or SUB R1. If you have a SURF, bring the SURF transducer antennae near the unit you are testing. Ultrasound waves can penetrate in the air too, provided that the distances are very small (best if no farther than 1 meter). Following the verification that the SUB T1 unit is transmitting, repeat the same test inverting the roles.

If all of these tests are successful, the only thing left to do is finish your preparations and get in the water.

Check that the SUB T1 communicator is firmly mounted on the full-face mask (firmly fastened NACS, O-ring present on the NACS, adjustment of same), that the strap is adjustable, and that the surface breathing valve is open.

Enter the water wearing the mask equipped with a communicator. With conventional masks, the receiver can be attached to the strap.

6b - **Receipt and transmission tests before the dive**

The tests run before the dive should be repeated on the surface of the water.

1. Check that all the SUB T, SUB R, and SURF units are operational.
   The user wearing the SUB T1 full-face mask tilts his or her head to the left to wet the two contacts on the case so that the communicator turns on (you will hear a beep every time the contacts get wet). Then press the button to call the surface station or a dive buddy, as follows:

- Press the PTT and listen for the activation beep = ***the unit is powered and the PPT works.***
- Wait a few seconds after the beep and then speak (example): "George transmitting, everything's okay, over."
- Then request that the surface unit send a brief message: **"Surface to George, reception level (0 to 10), over."** The quality of this transmission must be verified by the diver, who responds, saying: **"George to surface received, quality (0 to 10), over."**

Having verified that all units can transmit and receive, it's time to begin the dive.
It's always a good idea to conduct these checks BEFORE beginning the dive.

6c - Basic rules for underwater communications

1. Before beginning the dive, if there are more than two divers on the system, a communications sequence must be established (who speaks first, second, and so on). Everyone needs to know who comes before them and who is next in the conversation. This sequence is important to prevent communications from multiple divers overlapping when two or more start speaking at the same time.

2. Press the button to begin transmitting. After hearing the activation beep, wait a few seconds before speaking. The purpose of the beep is to attract the attention of other divers and/or people on the surface. If you speak over the beep you may not be understood because others are not paying attention or because a portion of the conversation overlaps the beep itself.

3. Speak slowly and pronounce your words carefully. Speaking into the nose/mouth pocket (when wearing a mask) causes reflections and changes in the tone of your voice. Try putting your hands around your mouth like a shell and then speaking. Anyone who hears you will immediately notice the change in tone. Your speech is less clear. Underwater, this obstacle is joined by the element of water surrounding you, which "compresses" your tone of voice downward. That means that you should speak at a normal level, but speak slowly and pronounce each word very clearly. Otherwise your words

will get jumbled together and be difficult to understand. This is fairly common even in conversations on dry land with people who speak quickly, or who have accents and pronounce words inaccurately and as a result are difficult to fully understand. This is why you will notice that the voice of the person on the surface is much clearer than those of the divers. Keep in mind that in order to hear as well as possible, divers will preferably hold their breath for short periods or breathe more slowly after hearing the beep that announces communications will begin. It is therefore advisable for people on the surface to speak in short sentences, using brief and clearly pronounced communications.

4. Every communication should end with the word "over". This alerts all participants (by clearly defining the end of the communication) and gives them confirmation that they can begin their turn speaking.
5. After the end of a transmission, it's a good idea to leave 5 to 10 seconds of silence so that anyone who urgently needs to step into the conversation may do so. After the 5 to 10 seconds of silence, the next person in order speaks (see point 1).
6. In a group, it's a good idea to start your communications by stating your own name followed by "transmitting", thus: "George transmitting".
7. Air bubbles create a barrier against ultrasound waves, and as they break into micro-bubbles, they tend to adhere to the antenna of the communicator. These micro-bubbles can reduce the range of communicators by up to 80%. That means that during the dive you need to take a few countermeasures.

a. Every so often, it's a good idea to run your fingers along the antenna on your communicator to remove the micro-bubbles that have stuck there.
b. You can also spread a thin layer of silicone grease on the antenna. Silicone makes it more difficult for the air to adhere to the plastic.
c. You can direct the flow of air you exhale away from the communicator by turning the swiveling discharge valve to the opposite side.

8. Knowing your dive buddies and being used to how they speak helps you understand. A person I speak with every day out of the water will understand me much better than a stranger, even underwater. (To an even greater extent, a person with whom I speak often underwater will understand me even better.)

6d - **How to breathe underwater**

- Speaking requires greater air consumption. You should always keep this in mind when planning your dive. It's a good idea to calculate a 10 to 15% increase in consumption due to conversation. Some people mistakenly think that full-face masks lead to higher consumption, but that is only true if the mask has leaks (which should be eliminated before the dive) or if it provides continuous flow. In all other cases, after an initial acclimation period, consumption returns to the levels of a normal regulator.

"Speaking" means consuming more air!

- You'll need to practice underwater communications, and learn to speak while exhaling slowly (see the next chapter). The faster or stronger you exhale, the more bubbles you create. Bubbles create noise, which deteriorates the quality of the sound by creating vibrations and sounds that drown out your speech. They also create noise that can cover up or muddle what you hear. It's a good idea to practice keeping control over the quantity and intensity of bubbles you make when speaking.
- Even when you're just listening, you should still breathe slowly, and hold your breath for brief periods if necessary.

6di - **Controlled breathing**

When you talk, large quantities of CO_2 are emitted. This gas is crucially important for activating exchanges with oxygen on the cellular level and the resupply of oxygen to the cell. With carbon dioxide, "CO_2", in the body at approximately 6.5%, and outside in the air that we breathe at 0.03%, a **fast "movement"** is created in which this gas moves in the **maximum/minimum** direction trying to achieve equilibrium.

This results in large losses of carbon dioxide, which is crucial for the optimum exchange of gases at the cellular level. In fact, oxygen can only be "delivered" to the cell thanks to the presence of CO_2, which has the ability to "detach" it from the red blood cell and send it to the center of the cell, thereby resupplying it with its precious fuel.

People who speak a lot (and poorly), either by profession or for some other reason, get to the end of the day feeling exhausted and worn down, and this fatigue is caused by the loss of CO_2 due to speech and excited breathing through an open mouth. The result is that the cells are not well supplied with oxygen, and like any engine, without fuel it simply doesn't go. Our bodies feel tired... very tired! Therefore, it's very important to be aware of how you speak, AND ESPECIALLY UNDERWATER!

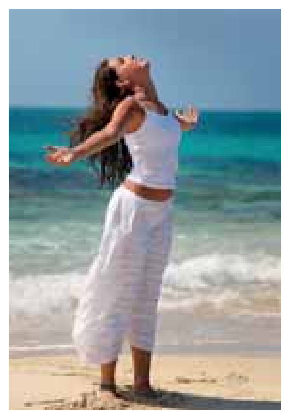
We need to apply the controlled breathing technique, which allows us to:

- Maintain good physical condition
- Use less air
- Make our communications more intelligible

To begin breathing correctly, we draw a large quantity of air into our lungs, being careful not to over-expand our rib cage or raise our shoulders. Instead, we push the inhaled air toward our bellies, feeling the sensation of having a ball inflate in the belly (this method also directs the inhaled air to the lower part of the lungs, forcing the diaphragm to move downward as it is pushed by the lungs).

Proper breathing should be done using the entire lung. However, these days we only use the upper part of our lungs. We leave the lower parts of our lungs unused. This reduces ventilation and the beneficial effects of breathing. When the lungs fill completely, they take on a greater volume, and therefore occupy some of the space usually reserved for your internal organs. The result is that your abdomen swells outward, your lower ribs open laterally under the force of the air contained in the lower part of your lungs. Your diaphragm also moves downward under a force proportional to the amount of air stored in your lungs.

So, we hold the air in for a few seconds and then begin to empty the lungs while pronouncing the sound of the letter "O" (pay attention to the position of your mouth; exaggerate the movement so that your mouth takes on the roundest possible shape).



When we decide to exhale, we need to keep our abdominal muscles well toned in order to provide the correct pressure on the diaphragm and thereby regulate the emission of air precisely as we want, emptying the lungs at a steady, prolonged rate. The flow of air emitted should be as even as possible. An old trick for checking whether you're doing well in your practice is to exhale air over a candle flame. If the flow is steady, like it should be, the flame will remain bent at a constant angle. If it bobs up and down, the flow of air is not steady.

Make these movements slowly; don't be in a hurry to inhale or exhale. To see if you are breathing correctly with your diaphragm, stand in front of a large mirror and take a good deep breath. If your shoulders rise, then you need to take another look at your breath: it's too high. If on the other hand when you take a deep breath your shoulders do not move or shift only a little, and the air you inhale inflates your abdomen (this happens because the lower part of the lungs are inflating), then everything is fine and your diaphragmatic breathing is correct. Now you only need to apply it to phonics: talking!

Here's another preliminary exercise:

1. Close your eyes.
2. Take a deep breath, slowly counting to three in your head.
3. Push the air you breathe toward your belly, and slowly more and more until you completely fill your lungs.
4. Hold your breath for about 3 seconds.
5. Don't rush; take your time.
6. Exhale slowly, counting to five.
7. Don't force your breath too much, but keep it fluid and steady.
8. Repeat.
9. Focus your attention on that spot in your belly that rises, and follow it up to your chest.
10. Use your nose to inhale and your mouth to exhale.
11. Stay calm and relaxed.
12. Focus on your breathing and try to repeat the exercise for 10 minutes.

Now, we'll repeat our exercise, but during our slow, controlled exhale, we'll say a few sentences. When speaking, keep your tone even and minimize your exhalation. Repeating this exercise a few times, we notice that we continue to extend the length of the sentence we speak as we exhale.

Underwater this means a low, steady flow of small bubbles, making less noise and distortion. The quality and intelligibility of your communications will benefit.

6e - **Reduction of range in pools and oxygenated environments**

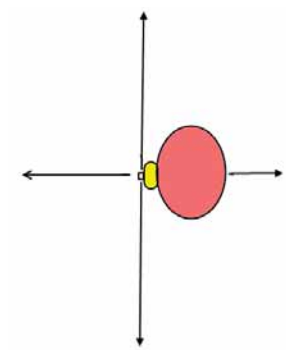
If communicators are used in a pool you may run into problems caused by the filtering system, which generates micro-bubbles of air, or because the air exhaled from the tanks in large quantities is partially dispersed in the water in the form of micro-bubbles. Solutions in this situation are:

- Suspend the filtering of water and stir up the water for a few minutes with pool brushes to bring the micro-bubbles to the surface.
- Disturb the water in any event to help bring bubbles to the surface so they can be eliminated.

6f - **Use of underwater communication units in closed environments**

Another obstacle in closed environments is the echo effect, or more frequently, audio distortion caused by excessive transmission strength. The transmitters are relatively powerful, and if they're used in a pool or very close to each other, distortion can be created. The audio goes "off the scale", and becomes difficult to understand. You need to reduce the power, by creating attenuators/filters on the antenna transducer. "Dampers" have been created that can be inserted on the antenna; they are made of a spongy material with many tiny air pockets. The combination of the two materials creates the filter needed to reduce the transmission power as needed and make conversation intelligible again. If you don't have a damper, you can use spongy material held over the antenna.

6g - **Directionality of transmission**



The ceramic on the transducer is a cylinder with its neutral axis perpendicular to the communicator. Transmission occurs as shown in the next diagram, with the maximum radial to the antenna and the minimum axial. In addition, there is a signal reduction zone caused by the skull and the body when the unit is worn on the mask. The skull, brain, and other tissues create a discontinuity in the matter surrounding the antenna, and attenuate the signal. It's true to say that the very best performance is achieved when you're face to face with the other party, but this is true even if that person is above us, below us, or behind us, while someone to the side, and particularly on the side away from the communicator, suffers the most deterioration in signal.

An easy, handy exercise for getting familiar with all the various aspects of underwater communications is to dive as a pair with two communicators. One diver begins talking, while the other turns in place, 360 degrees. Then switch roles, rotating 360 degrees while your buddy holds still. During rotation, it's important to repeat the same phrase each time and always use the same tone of voice.

In both cases you'll notice a marked change in reception volume. The very best performance is achieved looking at the other person directly or at 180 degrees, depending on the radial axis of the antenna transducer. This feature is especially useful for getting your bearings underwater or for locating a buddy or a boat that has a SURF unit installed.

6h - **POWER – INTELLIGIBILITY – RECOGNIZABILITY**

The power of a communicator can be expressed on two scales. The power of the amplifier (value in watts, but which is expressed as a "potential" more than a power, because it does NOT take into account environmental factors, which have a significant effect), and the propagation strength of the ultrasound waves, which is measured using practical tests (testing whether a signal is heard at x meters/miles from the emitter).

INTELLIGIBILITY is a crucial characteristic. What if you say "kelp" and but someone hears "help"?! Intelligibility always characterizes the quality (whether high or low) of an underwater communicator.

RECOGNIZABILITY

Every human voice has its own "vocal timbre", which when visualized looks like a sound track in which the frequencies, distortions, and everything else that characterizes and personalizes your voice can be detected. An excellent underwater communicator can combine all three of these characteristics.

Exercises that help improve the intelligibility of communications

Harmony in a group is a quality that can improve any endeavor. We'll now take a look at a series of exercises that will allow you to glean the very best performance from your communications during the dive.
In order to be successful, a group of musicians practices and fine-tunes their coordination. Each member senses what the others will do before it happens, thanks to habit and practice.

Intelligibility test using the Modified Rhyme Test (MRT)

Officially, the test is only available in English, but it is possible to create applicable modules in other languages.

The MRT is a table of 50 lines, and each line contains six words with similar sounds (help, yelp, kelp, etc.). Each diver receives this table. A reading sequence

is established in which diver A selects and reads only one of the six words on each line (such as "kelp"), marking it off on his table, and working from the first line he proceeds downward with a five second pause between each word. The diver listening has the same table, and using a marker ticks off each of the words pronounced (or at least the one that he thinks is correct). At the end of the exercise, the transmission and reception word tables are compared. The more words were understood correctly, the higher the level of communications intelligibility.

This exercise was created to verify the quality of communications between two units, and can also be applied in training among groups of divers who use underwater communications often (such as instructors at the same dive school).

This exercise should also be repeated between the underwater (SUB T) and surface (SURF) units, between SUB T and SUB R, and between SURF and SUB R.

Intelligibility is considered:

Excellent: if the listeners (both) understand more than 45 words.
Acceptable: if the listeners (both) understand more than 38 words.
Unacceptable: if the listeners (both) understand fewer than 38 words.

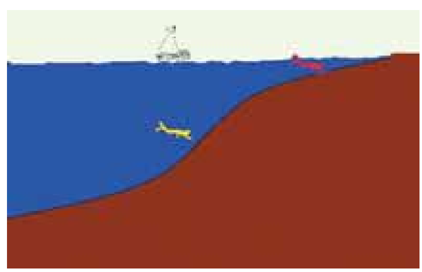
The test is considered invalid if the results between the two divers differ by more than 20%.

6i - Quality of diving communications in different environments and situations

To define the cases more clearly, we will always use the terms SUB T – SUB R and SURF.

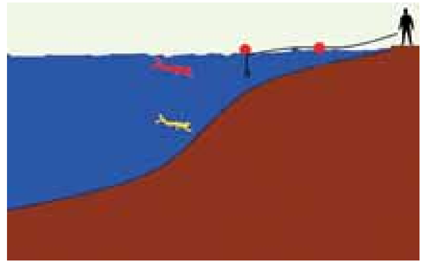
SUB T in shallow water, SURF or SUB R off shore

Ultrasound waves are reflected, losing power, and near the coast there is more air dissolved in the water thanks to the motion of the waves. In this case the transmission range may be low. If the SUB T is the guide, it's advisable for that user to stay near the SUB R in the early phases of the dive from the beach.



SURF on the shore and SUB T further off shore

It's advisable to use a small buoy and a weight anchored near the shore, and ties the surface communicator cable so that the antenna is held below the water's surface. Resting the transducer on the bottom not only reduces the transmission range; it also causes additional noise and wear as the transducer is dragged over rocks, sand, etc.



Rocks and algae

It depends on the structure of the rock, but if it is compact it tends to reflect sound, while types like coral tend to absorb it. In particular, the so-called "living rocks", full of microorganisms, are the perfect insulators of ultrasound waves. Algae, and especially those with reserves of air (such as Sargasso or kelp); create an additional barrier that attenuates the diffusion of ultrasound waves.

Open water and thermoclines

In general, communications in open water are excellent and save for the presence of drastic changes in temperature. In fact, the purpose of the length of the antenna cable for surface units is so that it can be placed at the best performing depth and getting past a thermocline when necessary.

What to do in a cave

Beyond all the precautions normally required when diving that are described in the various dive education manuals, communications in caves are either impaired or improved depending on the material the walls are made of. It's a good idea to maintain continual audio contact when entering a cave and to stop immediately if you notice the signal has dropped or the quality has deteriorated.

Wrecks

Follow all the applicable precautions described in the diving manuals. Communications inside iron wrecks can still be excellent so long as coral concretions and algae do not create thick layers on sheets of metal the sheets absorb and reflect ultrasound waves well. Biological strata function as an attenuating sponge. Air bubbles present or generated inside a wreck can be responsible for additional decreases in range and quality.

A SURF antenna can be placed on the bow or stern of the wreck, along the central axis and as close as possible to the horizon of the bridge of the wreck where most the activity will take place.

Position the SUB T unit on the mask

Communicators like GSM G Divers, GSM DC, GSM G Power, and old GSM STD models are equipped with NACS (Neptune Adjustable Communication Support), which allows you to attach the communicator to the band instead of the strap. This makes wearing the mask more comfortable, because the communicator does not weigh down the strap, pulling it out of line with the buckle, and does not press the unit too hard against the ear. However, it is important to assemble the NACS correctly to avoid weakening it or having it become uncomfortable and ineffective (the communicator "flaps" outward).

With the NACS it is possible to rotate the communicator twenty degrees and move it forward and backward a few centimeters. This allows the user to find the best location for the unit speaker over the ear.

Effect of the wetsuit hood

A wetsuit hood creates a distance between the SUB T or SUB R unit and the ear, and consequently it reduces its power. The thicker the hood, the more attenuated the signal will be. The G Power series has a volume control to solve this problem, while the GSM G and Power SL use a double speaker that can also be worn inside or outside the hood against the ear.

Exercises for communicating better underwater

General preparations

General preparations before a dive should always comply with the rules established by your dive instruction organization. Only after having completed all the preliminary dive safety steps should you focus on preparing your communication systems.
Apply, start up, and distribute the communicators to the members of the team with whom you'll be conducting the dive training.

Decide:

1. Team leader: the person with the most knowledge/experience necessary to teach others to use communicators with full-face masks. (This person must be a SUB T; they cannot be a SUB R or SURF). Define
2. SURF 0 – surface unit that will open communications (if present)
3. SUB T1, priority 1 (this is who will speak first when diver conversations begin)
4. SUB T2, SUB T3, and so on will follow in order.
5. SUB R (receiving units do NOT need an order of priority).
6. Explain that in the water, SURF 0 will make the first call, followed by the other SUB Tx.
7. Check that every SUB T, SUB R, and SURF unit works properly following the instructions on page 17/18.
8. Conduct the surface tests as described in the instructions on page 18/19 and make sure that all units assigned to each operator function correctly.
9. Begin the dive

DO NOT BEGIN THE DIVE WITHOUT:

- **having checked for complete communications between SUB T and SURF and SUB R (if using)**
- **having checked the assigned communications priority,**

The SURF begins:

"SURF (it's best to use one's own name) transmitting, verify communication quality. Please respond spe-

cifying the level of intelligibility from GOOD - NOT CLEAR. At the end of the test I will give the "GO" signal to begin."

If there is no SURF, the test will be conducted by SUB T1.

"SUB T1 (again, it's best to use one's own name) transmitting, verify communication quality. Please respond specifying the level of intelligibility from POSITIVE - NEGATIVE. At the end of the test I will give the "GO" signal to begin, over."

SUB T2 responds.

"SUB T2 transmitting, reception quality GOOD. Over."

And so on through to the final SUB Tx.

SUB T1 takes over communications again.

"SUB T1 transmitting, reception quality of: EVERYONE / (say the name of the person) is POSITIVE, quality of ..... NEGATIVE. Verify reception of SUB R unit. I will call you by name. Respond with a hand gesture according to the following signals if you understand what I am saying."

SUB R, confirm POSITIVE reception. SUB R makes an affirmative or negative signal.

SUB T1 checks the reception of each SUB R.

Having conducted the check, SUB T1 confirms if the dive will proceed or not, using the following words.

"SUB T1 transmitting. OK / I CONFIRM the dive begins. Meet... (At the bottom, at x meters). Position yourselves... ...."

Once you reach the meeting point, the real dive operations begin.

We recommend that you conduct an initial orientation session (in the pool or shallow water) to familiarize the operative members of the team with each other.

"Operative members" are the instructor, the dive master, and assistants, including those on the surface. In this harmonizing phase the SUB Rs are not involved, because they are considered to be students, who are accompanied during the dive and will need a short briefing and discussion afterward.

In the first harmonization session, all the SUB Ts and SURF will have the tables attached below.

TABLE 1 - TRANSMISSION / RECEPTION

	1	2	3	4	5	6
1	BAT	BAD	BACK	BASS	BAN	BATH
2	BEAN	BEACH	BEAT	BEAM	BEAD	BEAK
3	BUN	BUS	BUT	BUFF	BUCK	BUG
4	CAME	CAPE	CANE	CAKE	CAVE	CASE
5	CUT	CUB	CUFF	CUP	CUD	CUSS
6	DIG	DIP	DID	DIM	DILL	DIN
7	DUCK	DUD	DUNG	DUB	DUG	DUN
8	FILL	FIG	FIN	FIZZ	FIB	FIT
9	HEAR	HEATH	HEAL	HEAVE	HEAT	HEAP
10	KICK	KING	KID	KIT	KIN	KILL
11	LATE	LAKE	LAY	LACE	LANE	LAME
12	MAP	MAT	MATH	MAN	MASS	MAD
13	PAGE	PANE	PACE	PAY	PALE	PAVE
14	PASS	PAT	PACK	PAD	PATH	PAN
15	PEACE	PEAS	PEAK	PEAL	PEAT	PEACH
16	PILL	PICK	PIP	PIG	PIN	PIT
17	PUN	PUFF	PUP	PUCK	PUS	PUB
18	RAVE	RAKE	RACE	RATE	RAZE	RAY
19	SAKE	SALE	SAVE	SANE	SAFE	SAME
20	SAD	SASS	SAG	SACK	SAP	SAT
21	SEEP	SEEN	SEETHE	SEED	SEEM	SEEK
22	SING	SIT	SIN	SIP	SICK	SILL
23	SUD	SUM	SUB	SUN	SUP	SUNG
24	TAB	TAN	TAM	TANG	TACK	TAP
25	TEACH	TEAR	TEASE	TEAL	TEAM	TEAK

TABLE 2 - TRANSMISSION/RECEPTION

	1	2	3	4	5	6
26	LED	SHED	RED	BED	FED	WED
27	SOLD	TOLD	HOLD	FOLD	GOLD	COLD
28	DIG	WIG	BIG	RIG	PIG	FIG
29	KICK	LICK	SICK	PICK	WICK	TICK
30	BOOK	TOOK	SHOOK	COOK	HOOK	LOOK
31	HARK	DARK	MARK	LARK	PARK	BARK
32	GALE	MALE	TALE	BALE	SALE	PALE
33	PEEL	REEL	FEEL	HEEL	KEEL	EEL
34	WILL	HILL	KILL	TILL	FILL	BILL
35	FOIL	COIL	BOIL	OIL	TOIL	SOIL
36	FAME	SAME	CAME	NAME	TAME	GAME
37	TEN	PEN	DEN	HEN	THEN	MEN
38	PIN	SIN	TIN	WIN	DIN	FIN
39	SUN	NUN	GUN	FUN	BUN	RUN
40	RANG	FANG	GANG	BANG	SANG	HANG
41	TENT	BENT	WENT	DENT	RENT	SENT
42	SIP	RIP	TIP	DIP	HIP	LIP
43	TOP	HOP	POP	COP	MOP	SHOP
44	MEAT	FEAT	HEAT	SEAT	BEAT	NEAT
45	KIT	BIT	FIT	SIT	WIT	HIT
46	HOT	GOT	NOT	POT	LOT	TOT
47	NEST	VEST	WEST	TEST	BEST	REST
48	BUST	JUST	RUST	MUST	GUST	DUST
49	RAW	PAW	LAW	JAW	THAW	SAW
50	WAY	MAY	SAY	GAY	DAY	PAY

Each SUB T needs to be given as many tables as there are SUB Ts + SURF (3 SUB Ts + SURF = 4 tables). One table must be labeled TRANSMISSION, and on the others the word RECEPTION must be circled.

The location for the harmonizing/training session must be selected carefully. It must be easy to interrupt the dive, meet to verify results, and prepare for subsequent phases. A pool is excellent, but in that case the difficulties created by communications in closed environments must be taken into consideration. A beach or wharf can work well, and a convenient boat anchored to a shallow bed does too. It's a good idea to avoid deep or inaccessible areas or those with a current. It's always helpful to equip yourself with logistical supports like a floating basket that is anchored in which to store tables or pens, and a support where members can take a break without tiring. If using a surface unit, it should be fastened securely and protected. Make sure that the transducer does not touch the bottom, walls, keel or anything else in the operating environment.

If the SURF is present, SUB T1 calls the surface and invites it to begin the RHYME test, ending the message with the customary word "over".

SURF begins the test by asking each SUB T, one by one, to confirm that they are able to conduct the test. **This check must proceed through the following phases:**

SURF transmitting, will all SUBs confirm in their order of priority:

"All equipment is operating properly, physical condition is good. I confirm the beginning of the test, over."

The various SUB Ts respond, repeating the sentence *after saying their own name*. If conditions are not all positive, the test is aborted and the divers return to the surface to solve the problem.

Having reached the final SUB T, the SURF resumes control of communications and begins the test. When there is no SURF on the system, the procedure proceeds in the same fashion but with SUB T1.

SUB T1 begins to read one word of their choice from each line of table 1 – TRANSMISSION. ONE per line, randomly! On the TRANSMISSION table, use a pencil to circle each word read aloud.

Leave a 5-second pause between each word until reaching the 25th line.
On their own RECEPTION table 1, all the divers circle the words they believe were said by the SURF or SUB T1.
Upon reaching the 25th line, SURF or SUB T1 confirms the conclusion of the test and passes the turn to speak along the priority sequence, and the remaining divers repeat the transmission test in the same way. Each therefore will use the TRANSMISSION table 1 for the step in which they read, and the RECEPTION table 1 for each listening step.

This exercise must be conducted WITH BOTH TABLES by the members of the team. Between table readings, the dive must be paused so that results can be checked and discussed.

COMMENTS - ANALYSIS - GOALS

Comparing the TRANSMISSION table with the various RECEPTION tables can indicate which words were misinterpreted by other divers. This misinterpretation can be caused by a number of factors.

If every RECEPTION table has different errors, it may be only a question of familiarity among team members. However, if the same word was misheard by more than one diver, it may be that the problem is caused by an incorrect reading or pronunciation.

	1	2	3	4	5	6
26	LED	SHED	RED	BED	FED	WED
27	SOLD	TOLD	HOLD	FOLD	GOLD	COLD
28	DIG	WIG	BIG	RIG	PIG	FIG
29	KICK	LICK	SICK	PICK	WICK	TICK
30	BOOK	TOOK	SHOOK	COOK	HOOK	LOOK
31	HARK	DARK	MARK	LARK	PARK	BARK
32	GALE	MALE	TALE	BALE	SALE	PALE
33	PEEL	REEL	FEEL	HEEL	KEEL	EEL
34	WILL	HILL	KILL	TILL	FILL	BILL
35	FOIL	COIL	BOIL	OIL	TOIL	SOIL
36	FAME	SAME	CAME	NAME	TAME	GAME
37	TEN	PEN	DEN	HEN	THEN	MEN
38	PIN	SIN	TIN	WIN	DIN	FIN
39	SUN	NUN	GUN	FUN	BUN	RUN
40	RANG	FANG	GANG	BANG	SANG	HANG
41	TENT	BENT	WENT	DENT	RENT	SENT
42	SIP	RIP	TIP	DIP	HIP	LIP
43	TOP	HOP	POP	COP	MOP	SHOP
44	MEAT	FEAT	HEAT	SEAT	BEAT	NEAT
45	KIT	BIT	FIT	SIT	WIT	HIT
46	HOT	GOT	NOT	POT	LOT	TOT
47	NEST	VEST	WEST	TEST	BEST	REST
48	BUST	JUST	RUST	MUST	GUST	DUST
49	RAW	PAW	LAW	JAW	THAW	SAW
50	WAY	MAY	SAY	GAY	DAY	PAY

In this case, it's a good idea when training continues to repeat the reading of all six words on the line in which the word was misunderstood, reading randomly and marking next to each the position in which it was read/heard. Then the results must be compared.

These exercises must be repeated in order to improve mutual understanding among the team members as well as to alter both pronunciation and listening styles. For example, the divers will learn to hold their breath briefly when they hear that a communication is coming, and also to change their orientation compared to the others, how they exhale and emit bubbles, how they inhale, how they speak, how they analyze the surrounding environment, how often they remove bubbles from the antennae, etc. This is why it's important to mention once again that in order to remove these hurdles to understanding, team members need to follow the suggestions provided in these chapters. Indeed, the quality goals are achieved by applying all the notes provided in this course that explain the methods required to obtain the very best performance from the communicators.

Achieving mastery of underwater communications means adding an additional qualification to your list of professional diving skills.

It's a mistake to think that all you must do is wear your mask and press the transmission PTT to know how to communicate underwater. Although it's a simple operation, this technique can be intensified and analyzed in depth to obtain the utmost from the devices available and to communicate successfully in every situation. Underwater communications are, for all intents and purposes, a science that requires an understanding of physical phenomena and the appropriate use of the means that technology provides.

Repeat these exercises until the number of errors or misunderstandings is reduced to a physiological level (precisely as happens in conversations on dry land).

In the final analysis, it is possible to simulate any specific activity in one's own work (teaching an exercise, illustrating things or the environment) by carrying on a longer or shorter dialogue with your partners and ensuring that in the various positions/conditions, understanding is kept at good levels.

Remember that when you expect a response, you need to end your own transmission with "over", while if the conversation doesn't require a confirmation you should end with "out".

Diving with students or divers equipped with SUB R

This may be one of the most salient points of this course. One of the main goals of teaching underwater communications focuses on managing courses or accompanying students or divers underwater who, wearing conventional equipment, are equipped with receivers. Receivers make it possible to listen to instructions or directions from the instructor or guide, but clearly do not permit them to "respond" except with gestures and signals, which we'll look at shortly. This method is especially useful for many reasons, including:

- It offers the option to use underwater communications even with "non experts" who are learning to dive, and therefore are not yet prepared to use an integrated system (full-face mask with regulator and communicator).
- Allows students/accompanied divers to focus on what they're doing without needing to concentrate on managing communications as well.

- In mixed groups or with novices, avoids improper use of the communications system with transmissions overlapping and consequent confusion.
- It introduces "conventional" divers to a new and more sophisticated way of diving, allowing training organizations,

schools, and instructors to design a development program for their students and clients.

- It increases the safety of the dive by making participants feel confident because they receive clear, decisive instructions and input rather than signals, which necessarily limit interactions.

The team may be composed of:

-SUB T1 and assistants SUB T2 who have fine-tuned their understanding of each other SURF.
- A variable number of SUB Rs (divers who use/wear the receiver)

There are a number of different ways to use the receiver.

Group mode

The instructor keeps a receiver. Each time the instructor wants to communicate with a student/diver, he/she takes the receiver from the BC and holds it to the diver's ear, holding down the PPT button on the transceiver. The receiver should be kept in a pocket of the BC or connected to a carabineer, or even better to a retractor using a D-ring on the BC.

Shared mode

The group of divers is given one receiver for every "x" number of divers. We recommend initially limiting this type of sharing to no more than two divers. Pairs are established, and each one is assigned a receiving unit. The unit is then connected to a retractor and fastened to a front D-ring on the BC.

Individual mode

Each student/diver is given a receiver. The receiver is connected to the mask strap, either on the right or left as the user prefers.

It's a good idea to connect the receiving unit to the mask only after the student is familiar with using a dive mask and has practiced flooding and clearing the mask multiple times. In accordance with the teaching guidelines of each organization, we suggest that students repeatedly flood and clear the mask ALSO with the receiver connected.

In any event, the connection to the BC using a retractor is the solution that will least interferes with teaching methods. It should be noted that the receivers are strong enough to be heard even if they are not held directly against the ear. Sometimes they can be heard a few meters away.

Group preparation

It is crucial that each participant understands the special dive "sign language" that is used by their own teaching organization. If this language has not been learned or is unavailable, the students must be taught certain fundamental signals, described below.

OK

I DO NOT UNDERSTAND

"No" indicated by wagging the index finger back and forth is appropriate.

If this gesture is followed by pointing to the communicator with the index finger it means: **"I can't hear."**

Refer to the reference teaching material to learn the other signs.

Instructions before the dive – Breathing

The instructor/guide informs the students that individual and group communications will be conducted, and that:

1. When they hear the "beep" indicating the start of transmission, they must slow their exhalations by holding their breath briefly and paying attention to incoming communications. Stop and face toward the instructor.

2. If the communication is directed to you, reply using the signals described above.

3. Periodically check that there aren't excessive micro-bubbles on the antenna of the receiver, and in any case rub off the bubbles frequently.

4. If the communicator begins to beep every 30 seconds, the battery is running out of power. Move toward the instructor, point to the receiver, and make the signal for low air. This means that the RECEIVER is running out of power. The receiver will still be able to receive communications for quite a few minutes – see the corresponding instructions.

The steps required to check the proper operations of the equipment are the same as those in chapter 6.

Before the dive, the guide/instructor must run a final check on reception quality on the surface.

1. Indicate whom he wants to speak with.
2. Instruct this person to rest the receiver in the water and hold their ear nearby (if the receiver is fastened to the mask, simply tilt the head to the side until the activation "beep" is heard).
3. **Say**: *"your name" transmitting, testing communications, 1, 2, 3, testing communications. "Student name", confirm reception with an OK and nodding your head, over"*
4. The student responds with the OK hand signal, or "I don't understand".

If the check is successful the dive can begin.

As soon as the dive begins, and after the divers have acclimatized, it's a good idea for the instructor to address each of them by name and ask that they confirm reception again.

"Instructor transmitting: John, everything OK? Answer me with the OK sign, over."

1. If the dive is conducted using group or shared communications, the instructor needs to approach the student and help him or her hold the receiver to their ear for the first communication by taking their hand, guiding it to the receiver, and bringing the device to their ear.
2. Reception should then be tested leaving the receiver attached to the jacket to see if it is still acceptable (this would facilitate interactions at a distance). In all of these steps, speak slowly and pronounce words clearly.

During the dive, the guide/instructor must conduct a variety of tasks.

1. If the instructor is teaching, he/she must move through all portions of the lesson, while also integrating direct interactions, such as questions and explanations and alternating their speech with checks that their communications are being understood. Conversations should be brief, shorter than 30 seconds if possible.
2. Questions posed to the students should be simple, and require yes/no answers.

3. When you ask a student to "do something", you should comment on the exercise or task with a direct dialog (OK, that's right, you can continue, etc.). Speaking calmly and with short, reassuring sentences motivates students and makes their activities more rewarding. It's also easier to understand what to do and what NOT to do.

The use of a single SURF surface unit makes the activities with your group safer and more complete. The SURF must primarily address the instructor or dive master in the group. It's only appropriate to make general announcements if there are important communications for the entire group.

Communications should ideally begin with:

"*Surface unit here, I am _____, attention (name of the dive master or whomever is being called), transmitting, please confirm reception, over.*"

Or alternatively,

"*Surface unit here, general announcement, general announcement, your attention please. [Pause for a few seconds.] Begin general communication. [Content.] Over.*

Conclusion

In this reference book we have tried to bring together everything needed to build a true understanding of what underwater communications are and how they can be managed most effectively.

We believe that it's the new frontier in the development of both commercial and recreational diving. We think that this big shift has just begun and we're convinced that the growing application and use of underwater communicators will make it possible to make diving much safer.

We're also convinced that this evolution will be ensured by sharing the experiences of many divers around the world, and we invite everyone to send in their suggestions, stories, and ideas for developing and improving "the science of underwater communications".


OCEANREEF
connecting divers





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