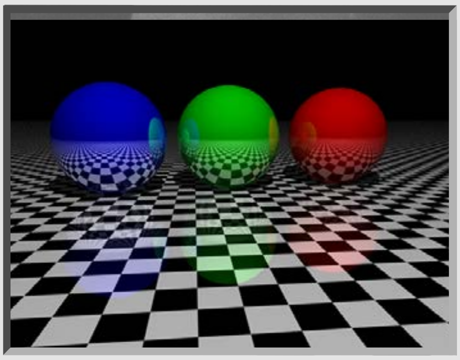
Manual Underwater Photography

Cameras & Housing



Physics, Psychology & Creativity

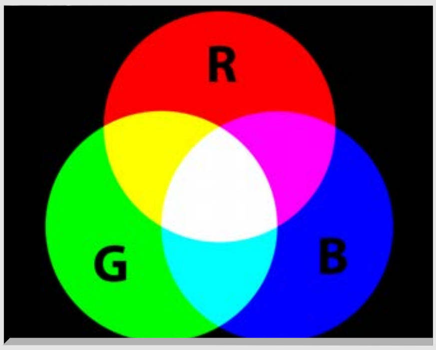


Image Sensors, White Balancing & Strobes

Preparation & Taking Pictures

SCUBA
Courses & Publications

Manual Underwater Photography
Scuba Publications – Daniela Goldstein
Jan Oldenhuizing

Table of Content

Introduction

We all have seen things underwater that we would want to share with others. Taking images underwater is a good way to do this. Pictures make the underwater world accessible for all – divers and non-divers alike. Taking the picture you want is not always easy. Photography is a matter of quantity and quality. Quantity refers to the amount of light needed to get the correct exposure and quality refers to the way the photographer brings this light into the camera. These can be seen as the technical and creative aspects of underwater photography (or photography in general).

This book takes you step-by-step through the technical background of photography and the challenges of underwater picture taking and provides suggestions for creative possibilities. The intent is to provide the information that is needed to take pictures in full manual mode (both for the strobe(s) and the camera). Digital photography has opened possibilities which were never available before. When using the right equipment in the right way, amazing pictures are possible.

The book "Underwater Photography with use of Automatic Functions" is meant for those who want to take nice snapshots without bothering too much with camera settings and the theory of photography. This book is meant for divers who really want to take-up underwater photography as a hobby. Manual photography requires substantial practice and training. Manual photography also requires that dives are dedicated to taking pictures. This book is not addressed to those who want to take occasional pictures.

The first chapters serve as preparation. The chapters on cameras & housings, physics & psychology, images sensors & white balancing and the chapter on strobes are meant to provide the background information that is needed as a basis for practical training. The chapters on preparation and photography & safety then serve to guide the gaining of experience in underwater picture taking.

Cameras & Housing

In order to take a picture, a photographer (or automatic functions from the camera) must manipulate the settings. All cameras have five key features. These are the image sensor (and its related sensitivity), the display (or viewfinder) that permits to frame the picture, the shutter mechanism and aperture to manipulate how much light enters the camera and the lens (defining the angle of acceptance and allowing focusing on the correct distance). For underwater photography, also strobe light must be taken into consideration.

All of these settings, as well as the way in which they affect each other, must be understood by a photographer who wants to take pictures with manual settings. For that reason this chapter starts with a detailed explanation of the basics of photography. Also experienced photographers (on land) should read this chapter, because for each item information is added that is specifically meant for making appropriate equipment choices.

Underwater, cameras are placed in a housing. The housing may make it impossible to adjust certain camera settings, or can obscure part of a picture. For underwater photography, it is necessary to take the features of the housing into account when considering the settings and technical options of a camera. This chapter is concluded with general information on housings.

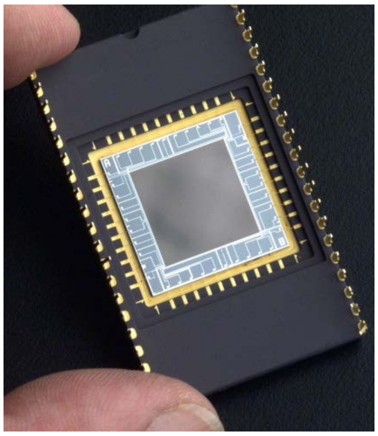
Introduction to the Basics of Underwater Photography

A camera can be seen as a closed box with an image sensor inside. A picture is taken by opening the box momentarily to let light enter. The quantity of light entering the camera determines if the picture is correctly exposed. Light can be allowed to enter the camera in different manners. The photographer uses these options to influence the appearance of the picture while still assuring the correct quantity of light to enter. There are six main features to consider when deciding on camera settings. Each of these will be covered in more detail in the following sections.

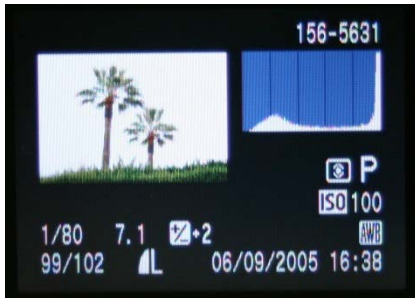
Before providing more detail, it is important to understand why the different features must be considered when buying a camera. The **lens** (or possibility to mount different lenses) is decisive for the quality of a camera. A shutter-lag (delay between pushing the button and activation of the shutter mechanism) is mainly caused by a poor performing autofocus motor. The lens is also decisive for the angle of acceptance and the minimum distance at which pictures can be taken. Wider angles of acceptance impose strobes that can cover the same area, while narrow angles of acceptance require relatively fast shutter speeds. Underwater it is not common to use a tripod and free-hand pictures must be taken while hovering in mid-water. Reduced chances to stabilise a camera must be compensated by faster shutter speeds. It is rare that the distance between the camera and the subject surpasses a metre and a half while taking pictures underwater. Closer is better. It is thus important to opt for lenses that allow pictures to be taken from close by.

Underwater the **aperture** has a stronger relationship with the strobe than with the shutter speed (as is the case on land). If the lowest setting on a strobe would be GN 3 and the smallest aperture would be 5.6, then (calculation follows in a later chapter) all pictures taken at a distance of less than 50 centimetres would be at risk of being overexposed. Manual photography with strobe underwater requires that the aperture can be set by the photographer. It is an advantage when small lens openings are available. SLR cameras may provide openings as small as F/22 or F/32, but with compact and bridge cameras this is often not the case. To have only limited restrictions in distance (due to too intense light from the strobe), try to assure at least f/8 when selecting a camera (or a strobe that can be set for a very low GN).

The **shutter speed** used to be a complicating factor for underwater photography. Due to lack of stability, photographers should use relatively fast speeds (1/60 of a second or faster), but strobe photography provided an upper limit. Depending on the quality of the shutter mechanism, that could be some value in the range of 1/100 to 1/250 of a second. The upper limit results from the requirement that the mechanism (both curtains) are completely open when the strobe flashes. When too fast a speed is set, only part of the picture will be illuminated by the flash from the strobe. This left the photographer with a rather limited range of options. With most digital SLR cameras, this restriction is still a limiting factor. Compact and bridge cameras have an electronic shutter, which allows the use of fast shutter speeds with a strobe. To make optimal use of the extended availability of shutter speeds, it is an advantage when the recommendation for a shutter speed (based on available light and a given aperture) is clearly indicated on the display.

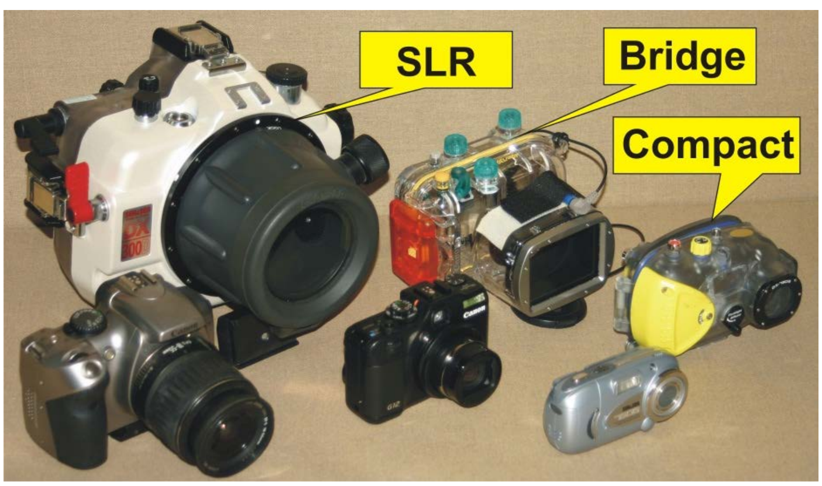


The **image sensor** does not only define what the maximum resolution of pictures will be (pixels). Combined with the processing and storing capacity of the camera, it can be that pictures can only be stored in jpeg format. It may however be desirable to be able to opt between storing in jpeg or raw (or both). Calculations for photography with an external strobe become easier when the sensor can be set for ISO 100 (sensitivity). The size of the sensor has an influence on the angle of acceptance of a given lens (will be explained later). The related electronics in the camera define the options that are available for white balancing. If you want to store the pictures directly in the camera in jpeg, it is important that the camera has the option to do white balancing on a picture that is already taken (not real-time manual white balancing). If you will only store in raw, this criterion is less important.



The **display (or viewfinder)** allows you to frame the picture. At the same time it should provide useful information to aid in deciding on the camera settings. After a picture is taken, the display should allow you to view the quality of the picture. With SLR cameras it may not be possible to use the display for framing. In that case the display is only used for verifying the picture after it has been taken and the viewfinder should now be used for framing and provides information to aid in camera setting. The use of a viewfinder is complicated when you depend on glasses for reading. In shallow water, the information on a display will be hard to read when it is not possible to protect the display against ambient light. For verifying the result of a picture that was taken, it can be helpful to have a histogram (the graph in the upper right corner).

An **external strobe** must be adapted to the aperture set on the camera. The most convenient way would be if the camera and the strobe communicate. This would require the strobe to be connected via a cable, which is normally the case for SLR cameras. It also requires that the camera and the strobe "speak the same language". Compact and bridge cameras do not always have a connection for a strobe-cable (even if the camera has, the housing may not allow the connection). An alternative is to trigger an external flash via a fibre optic cable (synchronising with the flash of the internal strobe). Finding a well-adapted and reliable combination of a camera and external strobe may prove to be the most challenging aspect of selecting equipment for underwater photography.

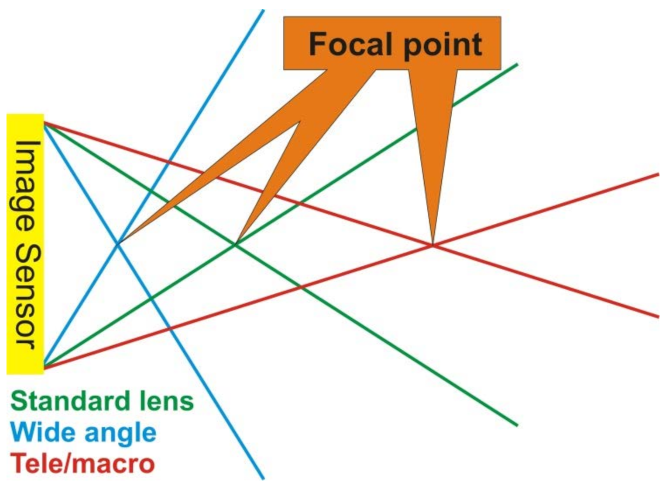


In this book we often refer to SLR, bridge and compact cameras as three distinct categories. SLR cameras are single lens reflex (the viewfinder uses the same lens as for taking the picture). Compact cameras share some features with SLRs. They have buttons for diverse camera settings (which avoids having to enter the menu for changing a setting), but use a display rather than a viewfinder for framing a picture. In most cases they do not allow using different lenses and make use of an electronic shutter (rather than a mechanical one with curtains). Compact cameras have only few buttons and require the user to enter the menu for most changes in settings. This makes their use very time consuming. On top of that, many compact cameras do not have essential settings available (such as defining the aperture, taking pictures in raw or manual white balancing on a picture already taken).

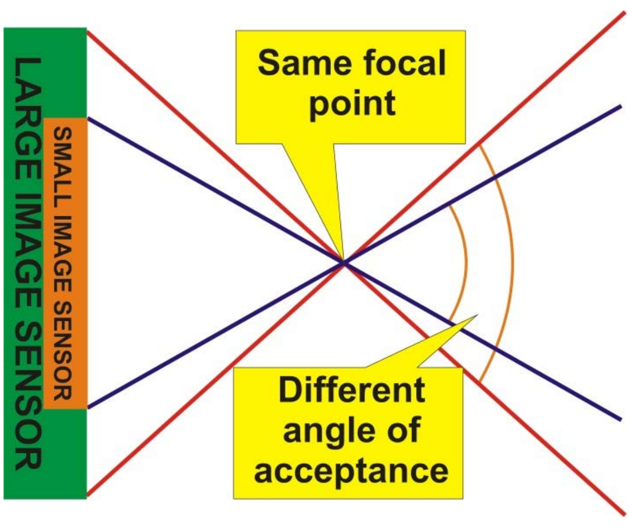
The above may give the impression that there are three clearly defined categories of digital cameras. This is not the case. There is a full range of models available and sometimes it is hard to tell if a camera still is a compact, or should already be considered a bridge. It will take some time to verify the features of different cameras before making an appropriate choice.

Lenses

Different lenses are defined by their angle of acceptance. As a human being sitting or standing at a certain location, we can see a specific area (when not moving our head or eyes). If a lens is "seeing" the same, it is called a standard lens. When we would need to move our head or eyes to see the same the lens is "seeing", it is called a wide-angle lens. When the lens is only "seeing" a fraction of what we see from the same position, the lens is called a telephoto/macro or just telephoto lens (there are some requirements to be met for naming a lens a macro lens, which we be discussed later). A lens can either have a fixed angle of acceptance or be a zoom lens. A zoom lens allows you to alter the angle of acceptance. Without changing the position of the photographer we can increase or reduce the area that gets in the picture. With a fixed angle of acceptance, the photographer needs to approach the subject or move away from it, to change what area is getting in the picture.



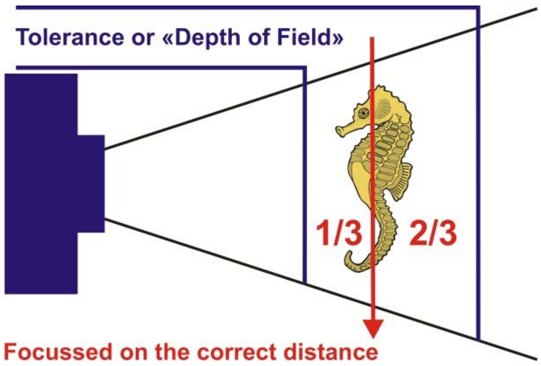
Lenses are not named by their angle of acceptance, but by the distance between the image sensor and the focal point. The focal point is the point where all light beams getting in the camera cross each other. Because the light beams cross at the focal point, the image is projected upside down on the image sensor.



This means that a 50mm lens has a distance of 50mm between the image sensor and the focal point. In traditional photography with the (most popular) 35mm film, at the surface this would be a "standard lens". This name is chosen because the lens covers exactly the area that the photographer sees. Unfortunately the difference in size of image sensors complicates things a bit. A lens changes the angle of acceptance when the size of the image sensor changes.

The size of the image sensor or film and the focal length of the lens define the angle of acceptance. For many years, most photographers have been using 35mm film and through the years they have gotten used to the angles the different lenses would cover. In those days it was clear that a 50mm lens was a standard lens (seeing the same as the photographer), that a 135mm lens was good for portraits and that a 35mm lens took pictures in the same angle underwater as the 50mm lens at the surface.

With digital photography this has all changed, because of the difference in size between the traditional film and the image sensors. To make it easier for the photographer to still benefit from experience gained with traditional cameras; most digital cameras give a conversion rate. This could for example be 1.5. That would mean that a 50mm lens will now have the angle of acceptance of a 75mm lens in traditional photography.



A lens needs to be focused on the correct distance. Most digital cameras do this automatically, but in some situations you would prefer focusing manually, by setting the lens for the correct distance. There is always a margin of error, called "depth of field". Everything falling outside of the depth of field is not in focus.

The depth of field is an important tool in the creative aspects of photography. On first thought one could think that "the more is in focus, the better it is". In photography this is not always the case. Especially in underwater photography we try to take pictures of creatures that are well camouflaged and are hard to recognize in their natural environment. The depth of field is a tool that allows us to take a picture with the creature in focus and the back-ground (reef or sand-bottom) out of focus. On land the same technique is used for portrait photography.

The tolerance, or depth of field, is different with different lenses and different settings on the camera. A wide-angle lens typically has a big depth of field (in many cases from close to the camera up to the moon) and a telephoto lens has a small depth of field. The influence of the camera setting on the depth of field will be explained after the discussion on aperture. In any case, a photographer should be aware of the depth of field of the lens he is using, to make use of this tool in the creative aspects of photography. The tolerance extends further behind the subject than on the side of the camera (one third at the side of the camera and two thirds away from the camera).

The minimum distance on which a lens can focus (depends on the quality as well as the focal length) decides if it is a macro lens or not. The name "macro" can only be used for lenses that allow the photographer to get close enough to a subject to take a picture of something that is no more than three times the size of the image sensor. This is easier with lenses that have a small angle of acceptance than with wide-angle lenses. However, the angle of acceptance has no importance in the definition. A lens with a given angle just needs a minimum distance (at which it can focus) that allows taking image filling pictures of objects of the defined size. If the area shown in a picture is three times the size of the sensor, the macro is called 1:3. If the area is twice as large, the lens is called 1:2. A picture of an area of the same size as the image sensor or film would be called a 1:1 macro.

In theory, we could take all pictures we want with a single fixed focus lens. It would only be a matter of moving closer to the subject, or further away. Different lenses (or a zoom lens) are needed anyway. We are not always free in the choice of the distance we have to respect in relation to the subject. Underwater the visibility and loss of colour are limiting factors. They force us to go close to a subject. On the other hand we cannot get too close to creatures because of their tolerance for our presence. If we were to get too close, we would not be able to capture their natural behaviour. Because of the need to go close in consideration of loss of colour and visibility, wide angle lenses are popular in underwater photography.

Another reason to choose a different lens would be a wish for a specific depth of field. The longer the focal length of a lens is, the smaller the depth of field. The small tolerance allows for photos on which the subject is in focus, but not the background.

There are limits to the focal length we can use underwater. Underwater we cannot hold a camera as steady as on land and the use of a tripod underwater is not common. Lenses with a long focal length are sensitive to camera movement. Beginning underwater photographers should limit themselves to lenses with a focal length of no more than 80mm. Only after gaining experience should they advance to longer focal lengths.

For some underwater cameras there are lenses available that can be added underwater. Mostly these are wide-angle or macro lenses that are placed in front of the standard lens with which the camera is equipped. These lenses allow you to use the camera for macro and for wide-angle during the same dive. The use of these add-on lenses is not without challenges. Often the area "seen" by the wide angle lens is not covered by the strobe. That would make it impossible to take attractive pictures. Macro add-ons are often not needed because the average digital camera already has remarkable macro abilities.

Aperture

The aperture set on the camera is nothing else than the diameter of the hole we use to allow the light to enter the camera. The aperture is based on a hole which allows the "full amount" of light to enter, which is called "F". The opening is now indicated as a fraction of "F" (the F/stop). This means that F/1 is a complete opening. From that point on there is a series of "standard" F/stops that limit the amount of light that enters the camera to half of what it was in the previous step. To calculate these steps, you have to multiply by the square root of 2 (which is approximately 1.4). F/1, F/1.4, F/2, F2.8, F/4, F/5.6 and F/8.

Moving one step allows double or half of the light to enter, compared to the previous setting. F/4 allows two times as much light to enter with the same shutter speed as F/5.6. F/8 allows only half of the quantity of light to enter with a given shutter speed than F/5.6.

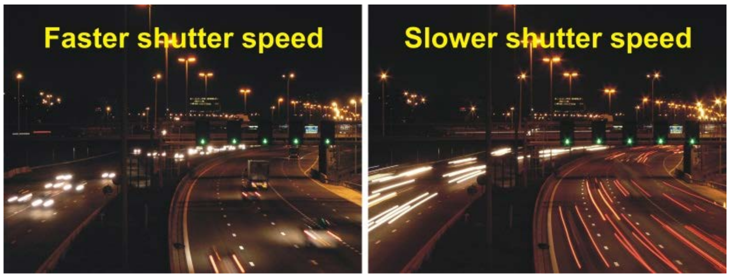
This means that the aperture or F-stop allows the photographer to adapt to situations with different light intensity. Compare a photo at mid-day with early evening or a photo in the garden compared to one inside. To measure the available light, most cameras are equipped with a light sensitive cell that either gives the photographer a recommendation for the setting of the camera, or provides the information directly to the electronics of the camera in order to do settings automatically.

Virtually all cameras with film and the better digital cameras have the standard series of F/stops (sometimes with intermediate steps). Compact cameras in most cases do not. They can have only few different F/stops, which may vary when zooming. For manual photography it is an advantage to have the standard F/stop series available. SLR models often have a complete range, up to F/32 (the possible apertures depend on the lens that is used). For bridge type cameras you should verify that there is a reasonable range of apertures available (up to at least F/8 because of the use of an external strobe).

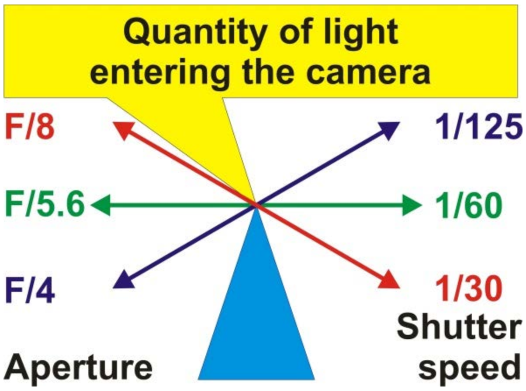
The amount of light entering the camera is not the only reason to change the setting for the F-stop. A small opening gives a big depth of field and a bigger opening a smaller depth of field. The choice of the photographer to have "everything in focus" or to isolate the subject from its surroundings by having the subject in focus, but not its surroundings, is also a consideration in deciding on the "correct" F-stop for the desired picture. This means that there must be other options to control the amount of light entering the camera. If only the aperture were available, the photographer would be forced to accept the depth of field based on the available light.

Shutter Speed

A second option to control the amount of light entering the camera is the shutter speed. The shutter is the mechanism that allows you to take a picture and is activated by pushing a button with your right index finger. The shutter opens and closes the camera. During the time the camera is open, light can enter. The camera can be opened for a longer period of time, allowing a lot of light to enter, or can be opened only momentarily, allowing little light to enter. The time the camera is open is defined by the shutter speed.



Shutter speeds are expressed in fractions of a second. 1/30 – 1/60 – 1/125 – 1/250, etc. On the camera these values are mostly indicated as 30, 60, 125, etc. which means that higher numbers allow less light to enter the camera. Changing the shutter speed allows the photographer to change the appearance of the picture. Again (just as with the aperture), the shutter speed is not simply a button to change the amount of light entering the camera, but also a setting for artistic purposes. Fast shutter speeds allow you to freeze movement. The picture is taken so quickly that a moving object is captured where it is. Slow shutter speeds allow you to capture movement. The camera is open longer and a moving object will be in the picture with its trajectory between the moment the shutter opens and closes. An extreme example of this is pictures of "red and white stripes" on a highway. These show the trajectory of car lights between the opening and closing of the camera.



Just as with the aperture, each step in the setting of the shutter speed allows half or the double quantity of light to enter the camera. This means that 1/100 of a second would allow the double quantity of light to enter compared to 1/200 and that 1/30 would allow half of what 1/15 would allow to enter. Between the F-stop and the shutter speed, the photographer can now find equivalent settings.

F/8 at 1/30 of a second would bring the same quantity of light in the camera as F/5.6 at 1/60 of a second. Whenever we double the quantity on one side of the balance (either the aperture or the shutter speed), we have to reduce to half on the other side. With this theory in mind we can identify many equivalent settings within the limitations of the camera and lens (minimum and maximum speed and smallest and biggest F-stop).

On first sight, this is an interesting option, but in underwater photography it is not always helpful. Underwater we are dealing with a few limitations that restrict our choice of shutter speeds. First of all we have to cope with movement. Hovering in mid water, we cannot hold a camera as steady as on land (with two feet on the ground). On land it is common to respect the rule of thumb, indicating that you should limit the shutter speed to "1 divided by the focal length of the lens" for free-hand photography.

That means that when using a lens with a focal length of 50mm, one should not take pictures at speeds slower than 1/50 of a second without using a tripod. Underwater the risk for movement is bigger, so we should apply this rule with even more caution. Slow speeds bring a high risk of blurred pictures due to camera movement (unless movement can be frozen by a dominating flash from the strobe).

On the other end we may be confronted with limitation. Most underwater photography is done with a strobe. If a camera is equipped with a mechanical shutter (curtains), there will be a maximum speed at which taking pictures with strobe is still possible. This maximum speed is called the synchronisation speed and should be mentioned in the instructions for use of the camera. Electronic shutters do not have this limitation. Those using a compact camera or bridge will mostly have an electronic shutter (the electronics activate and deactivate the sensor at the speed that is set).

Image Sensors

The amount of light an image sensor requires is expressed in ISO. There are fast settings (which requires only little light) and slow settings (requiring more light). By changing the ISO number, we can use a different aperture (at the same shutter speed) and get an equivalent exposure. Mostly the available steps double the amount of light that is required for correct exposure, or reduce the required amount of light by half. 100 ISO requires twice the amount of light compared to 200 ISO. 1600 ISO only requires half the amount of light 800 ISO would require. Digital cameras will indicate an ISO equivalent and most of them allow the user to select an ISO setting (often only in the manual programs).

The quantity of pixels a digital camera registers is an indication for the resolution we can expect (regardless of the ISO equivalent). A digital image sensor is made up out of thousands of small squares which are called picture elements (in short pixels). Each pixel records one colour. In digital photography we do not lose resolution when changing from one ISO number to the other, but a high ISO setting will result in noise. Noise refers to pixels that take the wrong colour. Noise can make high resolution pictures appear as if they were of much lower resolution.

The number of pixels (resolution) defines how big a picture can be printed or projected without allowing the viewer to see the individual pixels. The human eye has a resolution of 11.000 x 11.000 pixels (121 million) and a traditional 35mm slide is said to have between 4 and 40 million pixels, depending on the type of film. In digital photography the number of pixels varies.

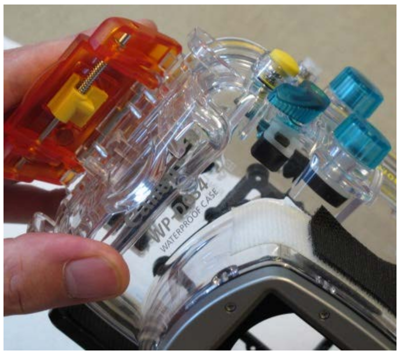
Strobes

A last option to alter the exposure is to add light from a strobe to the available light. Almost all underwater photography is done with a strobe. As a diver we are always dealing with less ambient light than at the surface. However, that is not the main reason for the use of a strobe. As taught in beginner courses for diving, colours disappear underwater, beginning with red. A strobe is used to bring the lost colours back. The intensity of the flash the strobe is delivering can be varied. This means that the intensity of the light coming from the strobe can be matched to a desired F-stop. A photographer can vary the amount of light the strobe is delivering either by using controls on the strobe, or by varying the distance from the strobe in relation to the subject.

If we combine all aspects we have seen above, then we can conclude that a photographer will wish to choose an F-stop or shutter speed and not be forced to take one just for the sake of getting the right amount of light in the camera. On land this is normally fully achieved by choosing a corresponding shutter speed, but due to the limitations of free-hand photography and (for those who use a SLR) the synchronization speed, this option is only a partial solution underwater. To increase the options and to show natural colours, one or more external strobes are inevitable in underwater photography.

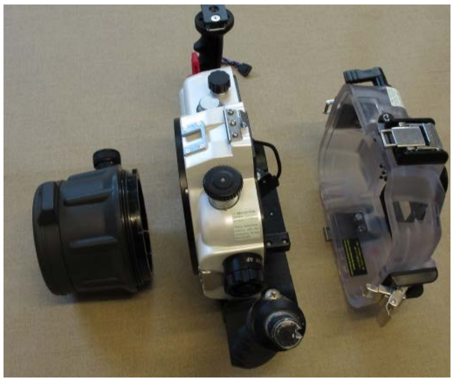
Camera Housing

The availability and quality of housings is an important criterion when buying a camera. Housings are not available for all cameras. For those that have housings available, this will not last. When a camera manufacturer discontinues a certain model, the production of housing will also be ceased. You are not likely to find a housing for a camera that you have bought several years ago. You should also take a look at the size of the housing before deciding on a camera. Some models are very bulky. The bigger the housing, the harder it will be to handle the camera during a dive.



For compact and (most) bridge cameras, the housing is rather simple, consisting of the main body and a cover at the back. Most such housings are made of plastic, with the port for the lens being made of glass. To seal the cover, there is one big O-ring that must be cleaned and greased by the user when preparing the camera for a dive. The port is in integral part of the housing and does not require maintenance by the user.

You should be aware that every passage, button or added part must be sealed just like the cover. This means that there are a substantial number of O-rings. Each of these could be damaged or pop out of its placement, resulting in flooding of the housing. This means that every dive should start with an inspection to see if bubbles come out of any part of the housing (if bubbles come out, water goes in). At the end of every dive, the housing should be rinsed in fresh water while manipulating each of the buttons. This way salt and other residue that could interfere with O-ring functioning is removed.



Housings for SLR cameras and some bridge models are made of three parts. Not only the back, but also the port can be removed. This configuration is used for cameras that allow the user to fit different lenses. When preparing the camera for a dive, both O-rings (back cover and port) must be cleaned and greased by the user.

If a camera has a removable lens, the aperture is part of the lens, rather than of the camera. In most cases the aperture can be adjusted via the camera controls, but in some cases (mostly non-original lenses) the aperture must be set directly on the lens. This (and manual focussing) requires it to be possible to turn the aperture and/or focus ring around lens inside the housing. If that is the case, the lens must be fitted with a clamp and/or sleeve (with some brands the sleeve is placed over a clamp).

A housing must allow you to manipulate all relevant camera functions once it is closed. Obviously you cannot place an SD card or replace a battery after the housing is closed, but other than that, all (or at least most) functions should be accessible. This does not always mean that all buttons on the camera should have a corresponding button on the housing. With many digital cameras, the same function can be accessed by different buttons. However, there are housings on the market that do not provide access to essential functions. This means that you should verify that all desired camera manipulations are possible.

It should also be possible to verify the camera settings. In many cases there will be an option to show all settings on the display from the camera, but even then it can be useful to have an alternate way of verifying that the camera is set as planned. The best way to verify if a camera/housing combination fits your need is to put the camera in place and then do a variety of settings.

Special attention should be given to the possibilities for attaching an external strobe. For SLR and some bridge cameras, there is a possibility to attach a strobe with a cable. In that case the strobe can communicate with the camera. The communication with the camera allows triggering the strobe at the right moment. It also allows the use of protocols that influence the intensity of the flash (the digital equivalent of the old TTL protocols). If such a protocol is used, the strobe must be equipped with the electronics that match the camera.

If a connection between the camera and strobe via a cable is not possible, a slave strobe must be used. In that case communication between camera and strobe is not possible. To trigger the strobe at the right moment, the flash from the internal strobe is used. To do that, a fibre optic cable is attached in front of the internal strobe and to a connector if front of a light sensitive cell on the strobe. The slave now fires at the same moment as the internal strobe.

The use of a slave brings up the issue of the pre-flash that is used by digital cameras. It should be verified that one of three options is available: 1.) The camera can be set for slave function in which case it does not pre-flash, 2.) The strobe can be set to ignore a first flash and only fire with the main flash or 3.) The strobe is fast enough to fire twice in a fraction of a second.

The intensity of a flash when using a fibre optic cable cannot be communicated by the camera. In this case the photographer must set the strobe (and the camera). If an automatic setting is used, the photographer must set the same aperture on the strobe as is set on the camera.

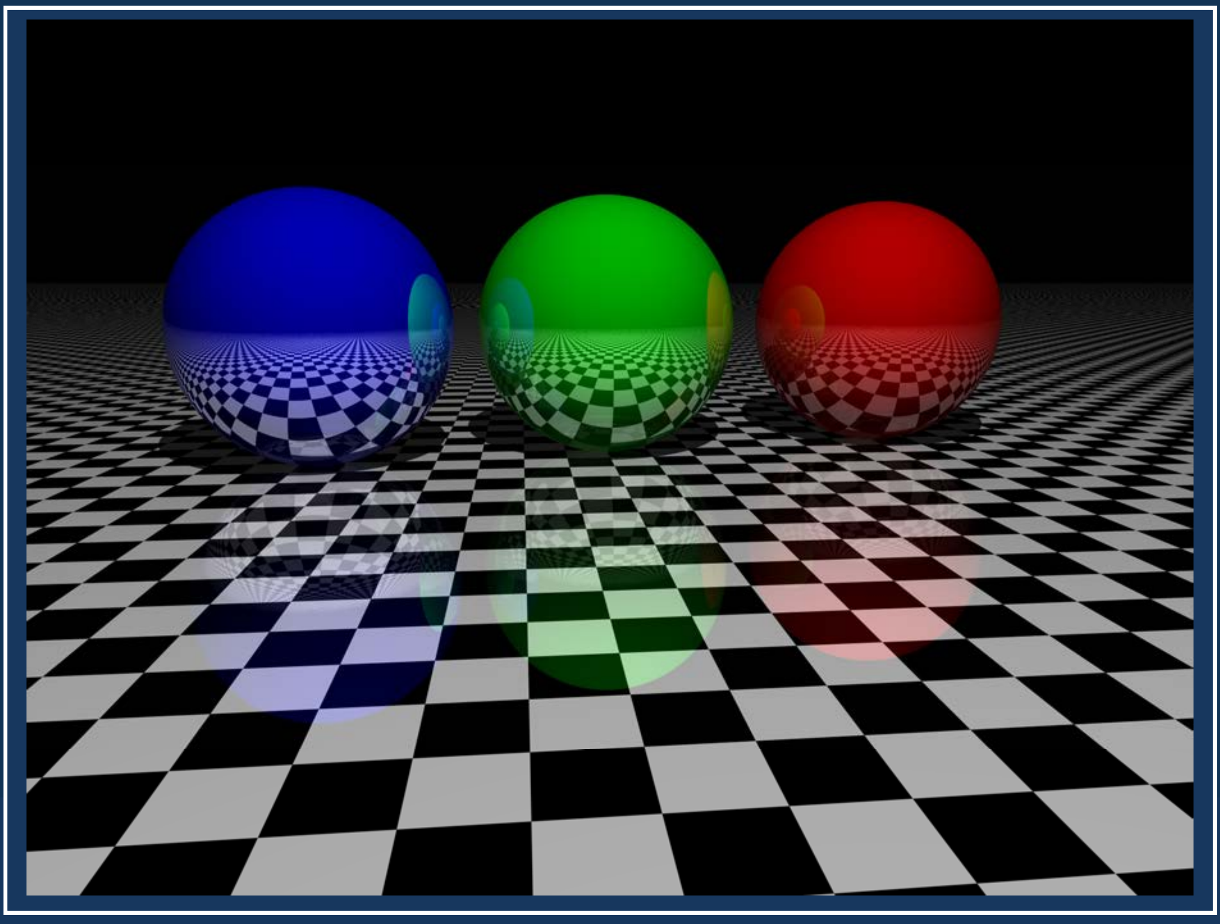
For manual strobe settings is does not make a difference if the strobe is attached via a cable or triggered with a fibre optic cable. In both cases the photographer must set the guide number.

Physics, Psychology & Creativity

Underwater the behaviour of light is substantially different than at the surface. This causes real differences (physics) as well as differences in the weight light is perceived (psychology). This chapter will address these differences and provide information on how a photographer can deal with these.

Some of the aspects of the behaviour of light do not play a big role when taking pictures on land, but do affect images taken underwater. Few of them are clearly a disadvantage. The underwater photographer needs to apply techniques to limit the consequences of the phenomenon. Other aspects may allow the photographer creativity in the way he captures light, that would not be possible on land. In any case, knowledge of the behaviour of light underwater is necessary for all underwater photographers.

It is also necessary to have knowledge of optical illusions. On land, pictures often reflect what you have seen while you were taking the picture. Underwater, optical illusions can play a big role. In many cases, the picture is completely different from what you thought you have seen. These illusions can be used to add creativity to a picture. You are not the first photographer to “be creative”. Various techniques have been tried and presented to the public. Some of them have been successful, others not. Without saying that you would have to copy creativity of others, this chapter concludes with some basic rules for pictures.

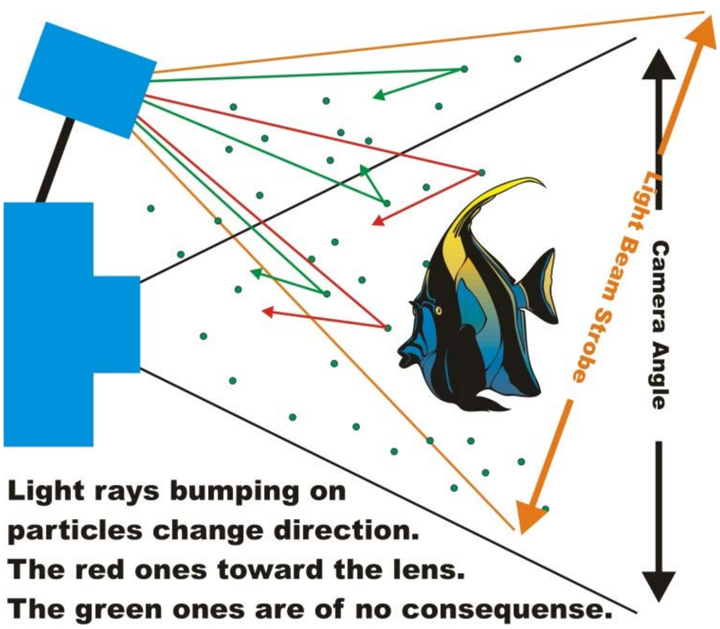


Diffusion

The consequences of diffusion are bigger than the other aspects of the behaviour of light. Diffusion results from light falling on particles and then changing direction. The more particles there are in the water, the more diffusion there is. Water is a more diffuse medium than air. Pictures will be affected by diffusion.

Because light is scattered in different directions, diffusion (and also absorption which we will discuss later) causes a loss of light with increasing depth. The deeper you go the less ambient light will be available to take a picture. This means that at greater depth, the camera must be set to allow more ambient light to enter (bigger aperture or slower shutter speed) if the background of the picture is to show blue water.

The scattering of light also has an influence on contrast. You can compare this with looking through the window in the living room, compared to looking through the window in the bathroom. When there are more particles in the glass, light will pass but, due to the scattering of light, you cannot see contrast anymore. Water has more particles than air, so you lose contrast. A basic rule is that you should not take pictures of objects that are further away than a quarter of the visibility (this is not the only limitation in distance for underwater photography).

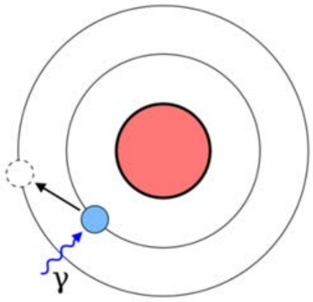


The most disturbing consequence of diffusion is that some of the light is scattered back in the direction of its own source and in the direction of the lens. This light then appears as bright spots in your pictures. In photography we refer to this phenomenon as "back-scatter".

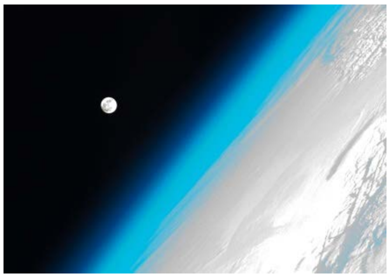
Back-scatter forces you to aim the strobe in a way that minimizes illuminating the water between the lens and the subject. Even more important is the angle under which particles are illuminated by the light from the strobe. For practical reasons (in reality it is more complex) you can imagine light from the strobe to either travel in the intended direction, or to return toward its source in a 30° cone. If the strobe is positioned high above the camera, the light beam is pointing down. Light being reflected back toward the strobe will not go in the direction of the lens, but pass above the camera. In this case, no back-scatter will be visible in the picture. The wider the angle of acceptance of the lens, the higher the strobe must be positioned above the camera (or to the side).

Particles that are closer than the subject will appear brighter in the picture than the subject itself when they reflect the flashlight. Particles that are further away than the subject have less importance, because the additional distance that the light has to travel through the water will decrease the intensity of the light. Particles that are further away are not (or hardly) disturbing in the picture. An internal strobe in a camera would illuminate all the water between the lens and the subject in the same angle in which the picture is taken. The consequence will be maximum back-scatter.

Back-scatter is the reason why underwater photographers use an external strobe that allows them to manoeuvre in a way that prevents the flash from lighting up too much water between the lens and the subject. This is why we use a bracket with a long arm for the strobe and in many occasions we even prefer to take the strobe in the left hand (camera in the right hand) to manoeuvre completely freely with the strobe (a technique called point shooting). The important thing to remember is that if your pictures show backscatter, the distance the strobe has from the lens is not enough for the angle of acceptance of the lens you are using. A longer strobe-arm is needed.



Another type of diffusion is molecular diffusion. Each molecule has unique characteristics with respect to light. If the energy from a certain colour of light corresponds exactly to the amount of energy that is needed for the molecule to bring an electron in a higher orbit, then the molecule will first absorb the light and then emit it again. Since the electron that was brought in a higher orbit will fall back to its normal orbit at another location, the light is changing its direction.



If there were no molecular diffusion, all light from the sun would travel in straight lines from the sun to the eye. We would see the sun (in the picture it is the moon) as a white spot against a black background. In the atmosphere the light bumps into oxygen and nitrogen molecules. The wavelength of blue light has exactly the right frequency to jump an electron from nitrogen into a higher orbit (in that action the energy of the light is absorbed). The electron will soon fall back into its original orbit, emitting the same blue colour. As the electron was orbiting, the light will be emitted in another direction then where it came from. Other colours of visible light have wavelengths that are not affected by this phenomenon. They reach our eye in a straight line. The consequence is that blue "comes from everywhere" and we have the impression that the sky (without clouds) is blue.

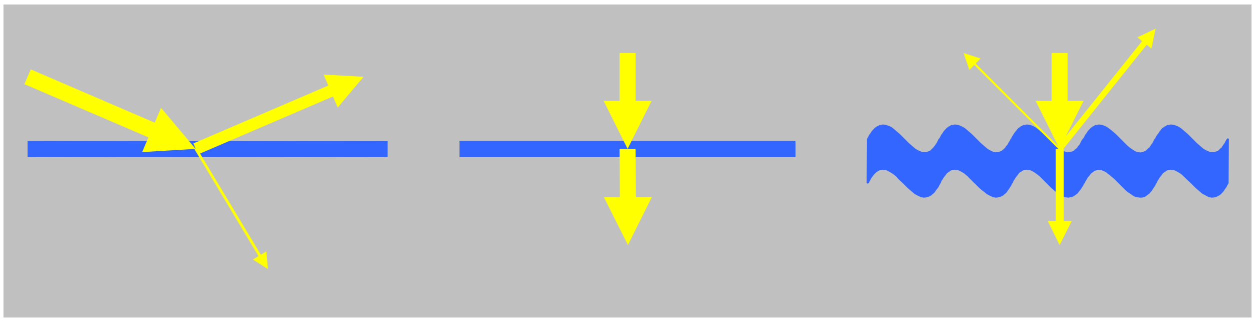
If there are many particles (clouds) also other colours will be scattered and we see white, grey or black. This causes the colour of clouds. There is another phenomenon you will have noticed. In the evening the sky can appear orange or red. This only happens when the sun nears the horizon. In that case, light from the sun has to travel through the atmosphere for a long distance. Since blue bumps from one nitrogen molecule to another, it cannot cover so big a distance. With the blue light having disappeared, the colour of the sky is defined by the other colours (red, orange, yellow).

The molecular diffusion of blue light is partly responsible for "noise". Noise refers to pixels that assume the wrong colour, making you picture look spotty or "pixelled". If a sensor is very sensitive (for example 1,600 ISO) it needs few photons (units of light) to be correctly exposed. Only a few "wrong" photons will visibly change the colour of the pixel. A less sensitive sensor (for example 100 ISO) would need to receive so many photons, that a few "wrong ones" would hardly influence its colour. Many of the "wrong photons" are blue and result from molecular diffusion within the camera and housing (where nitrogen is present). Another consequence of molecular diffusion is covered in the section on reflection.

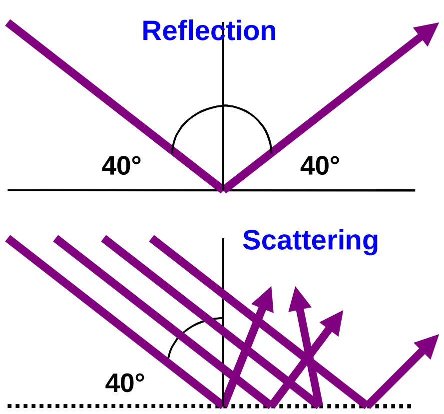
Reflection

The passage from water to air or air to water functions as a mirror. Depending on the angle under which the light is falling on the surface, a certain quantity of the light is reflected and does not penetrate the passage between the two media. As can be seen on pictures that are taken half at the surface and half underwater, there is always less light underwater.

For many pictures underwater, the photographer wishes the water around the subject to appear blue. For this, ambient light (sunlight) is needed. Flashlight only reflects on "solid" objects and not on water. It is the "filtering" of the sunlight that gives water the blue colour known from underwater pictures. If there is not enough light entering the water, it becomes hard to fulfil the wish of "blue water around the subject". This is why this type of pictures should be taken during mid-day and with mild surface conditions.



In the morning and evening, the angle of the light hitting the water will cause most of it to reflect. The critical angle is about 48°. Light falling on the water in steeper angles will pass into the other medium, but smaller angles are reflected. Be reminded that blue light is affected by molecular diffusion. Since blue "comes from everywhere", blue light can penetrate the surface even if the sun is standing low. In such a situation, pictures would lack colour even at shallow depth (if no strobe is used), because blue light completely dominates over other colours.



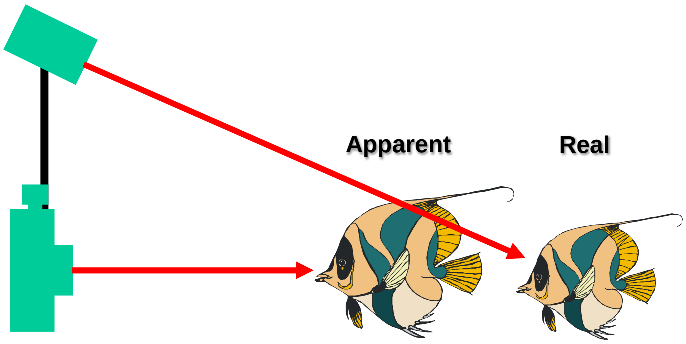
Theoretically we should only use the term reflection when the angle in which the light hits another medium is the same as the angle in which it parts. For the purpose of how much light penetrates the surface, this distinction is of no importance. At mid-day hardly any light gets reflected. That represents the best conditions for underwater landscape photography, provided that the surface conditions are calm. When there are waves, the water surface has an ever changing angle with the light and reflection becomes unpredictable.

This does not mean that you should only take underwater pictures at mid-day, in good weather (no clouds) and mild surface conditions. There are many types of pictures for which sunlight hardly plays a role. For close-up and macro photography, the object and its surroundings are often lit with flashlight only, as both the subject and its surroundings are "solid". Many macro pictures do not require ideal conditions with respect to the available ambient light.

Reflection is not always a disadvantage. You can use reflection to your advantage. There is not only reflection at the passage from air to water, but also the other way around. This means that you can use the surface of the water (or the mask of your model) as a mirror to add creativity to your pictures.

Refraction

Refraction means that light changes direction when it passes into another medium with different density. In underwater photography, we are dealing with light passing from water to the inside of the camera (air). This is the same as our vision as a diver underwater. Also here the light is passing from water to air (the air in our diving mask).



This means that the camera sees the same way as you as a diver. We see objects underwater larger and closer than they actually are. The camera must be set for the estimated distance. If we see an object at a distance of 1 meter, the camera will "see" it in the same way (regardless what the real distance is). For the strobe the situations is different. Light travels directly into the water and does not have to pass from water to air before it is reflected back into the camera. This means that the flashlight travels straight to the subject at its real distance.

For practical purposes, this means that you need to aim the strobe slightly behind the object you are seeing. That will be the real location of the object. In most cases, the area the strobe covers is bigger than the area of which the picture is taken. There will be a margin for error. With wide-angle photography the tolerance is less as the angle of acceptance of the lens could cover the complete area that is illuminated by the strobe. In those cases you must pay more attention to the aiming of the strobe. If you neglect this consequence of reflection, your pictures will be bright in the lower part and lack colour in the upper part of the picture.

A typical example using refraction for creative purposes is named Snell's window. With the term Snell's window we address a situation in which you see everything above the surface through a cone of light. You need a lens that can capture 97 degrees or more. The area around the circular shape will either be dark or show a reflection of the underwater world. Underwater you can compose photographs from below so that your subject is centred in Snell's window. This creates a clear blue background for the subject, while providing a darker circle as a sort of framing. To take this type of photograph, you depend on relatively calm surface conditions. In ideal conditions, when looking up at the surface, you can see a perfectly circular image of the entire area above water (from horizon to horizon).

Absorption and Optical Illusions

Light is energy. Water is a denser medium than air. When traveling in water, light energy is changed to heat. The first colour that is affected by absorption is red, which can travel no further than approximately three meters underwater. The human eye compensates for this loss of colour. If you see a can of coca cola at 15 meters depth, you will perceive it as being red. This is an optical illusion. It happens because your memory is added to your observations and you will "see red". The image that you think you are seeing is a mixture of what you currently see and what your brain adds to the scene. Since you know that a can of coca cola is red, that information will be added to the image from memory, rather than be processed over and over again when you see such a can. A camera does not compensate. It registers colours and shapes as they are. If you want colours to appear natural in your pictures, you must use a strobe.

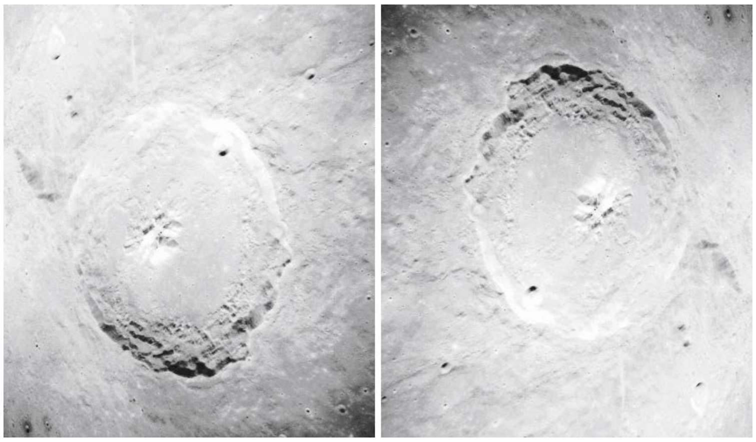
I ¶

As a matter of fact, you do not see all what you “see”. Close one eye and look at the opposite dot or star with the other eye (look at the left image with the right eye, or at the right image with the left eye). Start at about three times the distance between the two figures. Now move your head toward the paper and away again. At some point an icon will disappear, just to reappear at another distance. This is the “blind spot” in your vision. The little test is just to show that although you always “see” a complete picture, there are parts of the image that are actually missing. Your brain compensates for the things that you do not see at the moment by filling in the blanks from your memory. Much of what you see at the moment will not be what you actually see, but be a construct of your brain. Look at the image to the left. In one case your brain will identify the shape as an “H”, in the other case as an “A”.

Your eyes may be less preferment than you think. In shades ranging from white to black, the human eye can only distinguish about 30 steps of brightness. A normal digital camera covers 256 shades in the black up to white scale. When looking at the image below, you will clearly see five different shades of grey. Partly this is due to the ability of border detection (the abrupt change from one shade to the other). If you now place a pencil over the border between two shades, you will probably perceive the two adjacent shades to be the same. You cannot put too much trust in what you think you see.

Another aspect that can cause an optical illusion is the location where we expect shadows. As a kid you have perhaps held a torch under your chin to make a “scary face”. We are used to facial features of those we know, but always when illuminated from above. Changing the location of the light source can change an image to such an extent that we hardly recognise it anymore.

For photography the above has consequences for the location of the external strobe. It is common to place a strobe higher than the camera at the left hand side to achieve the most natural shadows. If two strobes are used, the dominant strobe is placed at the left above the camera. The smaller strobe that is used to soften shadows it also placed above the camera, but at the right.



The image to the right shows twice the same crater, but in one picture it appears to be a hill. And that is just because the shadow falls on the other side.

Light Beams do not Bend

Light beams do not bend, but travel in straight lines. They can be refracted, reflected or absorbed, but not travel in curves. This means that light from your strobe that is not reflected on your subject, or something solid behind your subject, will continue to travel through the water until it is completely absorbed. The light will not return to the lens and will have no influence on how your picture looks. If you find that your pictures are too dark, then a stronger strobe will not be of help. You need to find a way to get more ambient light in the lens.

Only strobe-light that is reflected on your subject or something in front or behind it will return to the lens. The strobe is used to illuminate the subject and its “solid” surroundings. It is the ambient light that is used to illuminate the water surrounding the subject. The light originates from the sun and passes through water, which functions as a blue filter. Hence, the rule is that the strobe is used to illuminate solids, while the sun is responsible for the colour of liquids and gases. Solids are illuminated from the side where the camera is and the water is illuminated from behind.

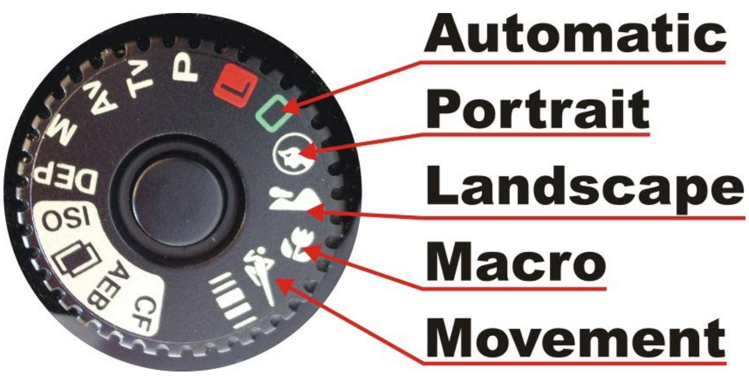
If you want a bright blue background, you need to take the picture in an angle that allows you to “catch” a lot of ambient light. A slow shutter speed and/or open aperture also help. This means that pictures for which you intend a blue background are normally taken in an upward angle.

If you take a picture in a downward angle with a lens with long focal length and if there is no solid background (the bottom or a rock), the background will show black in the picture. Again we are dealing with an illusion. If you look down over the edge of the reef, you might be able to see the bottom 15 metres deeper. The camera cannot. Ambient light cannot make a curve from its way down to the bottom to move back up to your camera. The distance is also too far to be covered by the light from your strobe. As a matter of fact, you can take pictures in the middle of the day that give the impression to have been taken at night.

For pictures with a solid background the ambient light does not make a difference. For that sort of pictures all the light needed comes from the strobe.

Creative Aspects

Photography is a matter of quantity and quality. The image sensor requires a specific quantity of light to record a “correctly exposed picture”. This is the technical part of photography. The calculations needed with respect to aperture, shutter speed, film speed and guide number for the strobe to bring the correct amount of light to the image sensor. As we have seen in the previous chapter, there are different options to do this. The choice of one of these options to bring the correct amount of light to the film or image sensor and the way you compose your picture are the creative aspects of photography.



There are no rules. Every picture is unique. As a photographer you try to create a picture that communicates something. You want to capture an emotion, a feeling, movement, energy or something else. It all depends on the reason why you took the picture. Using full **automatic** settings on a camera will not allow you to let your pictures communicate what you want to express. They will be "just another correctly exposed picture". This is the reason why many cameras offer some dedicated automatic programs.

In **portrait** setting the camera will select a big opening of the lens (low F/stop number) in order to have a limited depth-of-field to isolate the subject in a blurred out environment. The limited depth of field will leave no doubt what the subject of the picture is. Things in front or behind the subject will not dominate.

In **landscape** setting the camera will choose settings with a big depth of field. This will bring both the closer and the more distant subjects in focus. The camera will thus opt for a smaller opening of the lens to allow for a big depth of field.

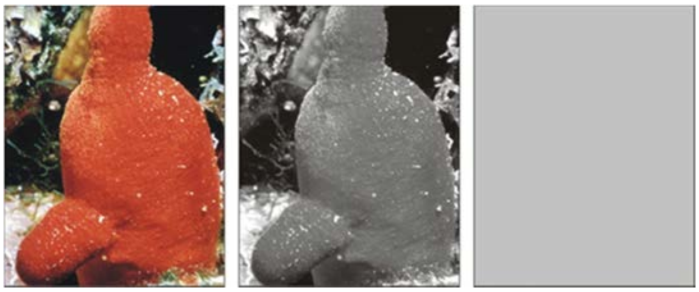
The **movement** setting is meant to freeze movement. The camera will opt for the shortest possible shutter speed. The moment the film or image sensor is exposed to light is so short that faster moving objects are frozen in the position they had the moment the picture was taken.

The flower indicates that the camera is set for close-up or **macro** pictures.

By setting one of the dedicated modes, you tell the camera what you need with respect to shutter speed or aperture and the camera software will take your needs into consideration when selecting the ratio between aperture, shutter speed, film speed and the use of a strobe. When using such a programme, the camera normally does not allow the photographer to interfere with the settings. As a consequence, you are not informed of the aperture selected by the camera. This makes it impossible to use a strobe that is triggered via a fibre optic cable (slave). Automatic programmes are thus only useful close to the surface (for pictures without strobe) or when equipped with a system that allows full communication between camera and strobe.

Next to the full automatic programs, there are "automatic assistance" programs. In that case the photographer is selecting some of the values and the camera electronics match the missing setting. In Tv (sometimes S for shutter), the photographer sets a desired shutter speed, film speed and if he wishes to use the strobe. The camera then matches the aperture needed for a correct exposure. In Av (sometimes just A) the photographer chooses the aperture, the film speed and the use of a strobe. The camera then matches the shutter speed for a correctly exposed picture. The "automatic assistance" programs can be very useful for snapshots. They allow the photographer to take pictures with settings that are done before (maybe even before the dive) with a relatively good change to have a reasonably exposed picture. In Av mode, the aperture is known, which makes it possible to use a slave strobe.

In manual mode the photographer sets all variables personally. The automatic functions of the camera are not used. This does not mean that you have to calculate or guess all the settings. The camera will still give recommendations on settings that match with the ones that you have on the camera and will tell you if (and sometimes by how much) a picture would (in the opinion of the camera) be overexposed or underexposed when taken with the current settings.

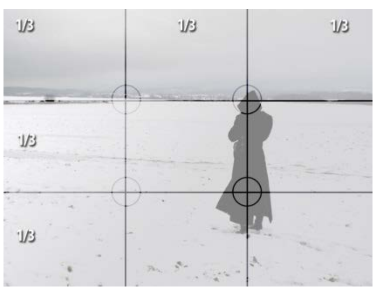


Both the automatic settings on the camera and the recommendations in manual mode have one bigger problem. Your camera wants everything to be 18% grey. The camera does not know what you are photographing. The camera sensors that are used for settings and recommendations cannot see colour. They cannot even see a grey scale picture. They just see grey. It is as if your picture were a painting and all the paint was mixed until it is averaged out to a single shade of grey. The camera then compares this grey with “normal grey” and gives recommendations based on that. These recommendations want either more or less light until the reflecting light is as it should be. The camera will want to turn the world into an (in average) 18% reflective environment.

Obviously not all situations average into “normal grey”, particularly not underwater. “Normal grey” is often defined as 18 per cent grey. This is an average of the world around us. If you would take a picture of a white sheet of paper, the camera would recommend settings that make the white paper appear 18 per cent grey in the picture. The same would happen with a black door. In a picture, according to camera recommendations, the door would be grey. If you would pin the white page on the black door to take a picture of the two together and if the relation between black and white surface areas would average to 18% grey, the two would appear real white and real black in the picture (if light measurement is set for average and not for spot).

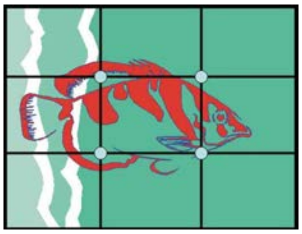
You need to be aware that automatics can only work with the information they have available, which is a light sensitive cell that measures available light and electronics that compare the measurement with a world with the reflection of 18 per cent grey. If you are in “another world”, corrections are needed. Many cameras have an exposure correction setting (EV). The setting allows you to inform the camera that the reflectiveness of the scene of which you take a picture is not normal. You can set for less reflective (darker) scenes, or more reflective (brighter) scenes, such as a landscape covered with snow.

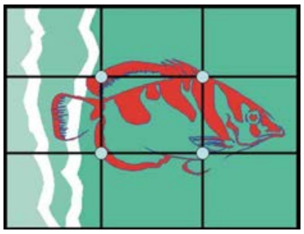
Although every picture is unique, there are some basic rules which can help to make a picture attractive. Photography is art and it is the artist that imagines and then takes a picture. The picture thus depends on the imagination and fantasy of the photographer, combined with the technical knowledge needed to take the picture as imagined. Through the years many photographers have experimented with composition and it has become clear that the general public finds certain pictures more attractive than others. This has led to some general rules for composition. But again – every picture is unique and you may find fantastic and attractive picture that are in conflict with all general rules.



The first general rule addresses the framing of the picture. This is called the rule of thirds. When you divide the surface of the picture in nine even parts, you create four points in the centre of the picture on which lines cross. The use of these lines creates more tension, energy and interest in the composition than simply centring the subject would.

The “third” also applies to other aspects such as headroom. In the pictures to the right, the mask from the diver (the main point of focus) is located at one third from the top of the picture. Compared to the pictures on the right and on the left, the picture appears to be more natural.





A second rule is to allow space in the direction of movement. Even if a fish does not swim (or a car does not drive), we see it as a thing that can move. The image on the left is more attractive, because the image at the right gives the impression that the fish is leaving.

People do not like to be stared at by other people. A picture in which a person is looking into the lens is perceived unpleasant by somebody who does not have a closer relationship with the subject. Ask your “model” to look at something else, which could either be part of the subject of the picture or not.

With animals, this is the other way around. People like to look at pictures of animals in which the creature is looking into the lens. Unfortunately it is harder to get an animal to look into the lens then it is to get a diver to look away from the lens. This will require some patience and is an important reason why you do not want a delay between pushing the button to take a picture and the moment the camera actually activates to take the picture. Some digital cameras have a rather long delay (shutter lag) and are not so suitable for underwater photography.

If the subject is a human being, then it is good to give the person a reason to be underwater. Ask the “model” to do something or to observe something. This gives the picture more “action”. A typical example is “taking a picture of a diver who takes pictures”. In that case you ask the model to set the strobe of his/her camera on slave function. The moment you take a picture of the diver, his strobe will also fire, which gives the impression that you catch the moment this diver takes a picture.

A picture must be complete. It gives a strange impression when part of a fish or a diver is missing. This does not mean it has to be “a complete fish”. It can also be a “complete head” or a “complete eye”. It is the subject that must be complete, but the subject can be a part of something.

Don’t forget to tilt the camera for pictures of higher subjects. In that case you should make sure that the strobe is still above the camera. As mentioned previously, we are used to see a shadow under a subject. If the strobe is lower than the camera, the picture will seem unnatural. In most cases this means that you tilt the camera in the position in which your “trigger finger” is under.

Diagonal lines make a picture attractive. If the subject offers you the choice of capturing it horizontal, vertical or diagonal, you may find that the diagonal picture is most dynamic and attractive.

Image Sensors, White Balancing & Strobes

It should be clear from the previous chapter that our mind is playing tricks on us. We see things that are not actually there, because our brain interprets visual information. If a friend wears a white shirt, you will see it as white, regardless if your outside in the sun or inside under artificial light. Of course you will still recognise extreme cases. A red spot lighting an artist on stage (wearing a white shirt) will make the shirt appear red. The more subtle changes (different colours or room lighting) go unnoticed by the human eye. The camera does not interpret the situation. If the room light is slightly yellow, all white surfaces in the picture will appear yellow. The required correction is called white balancing.

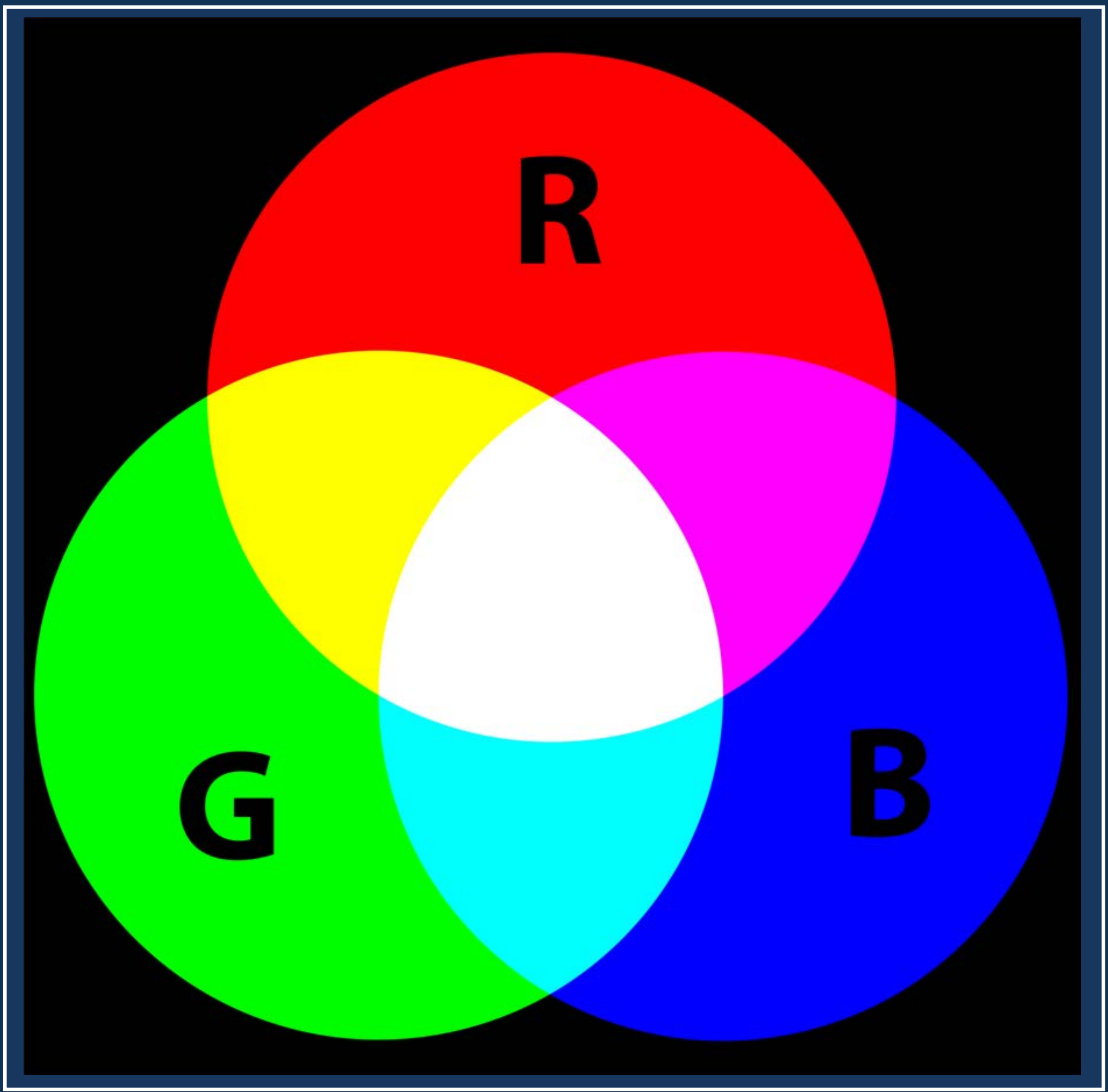
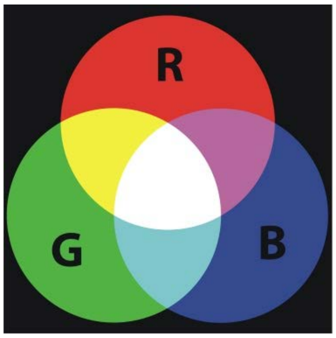
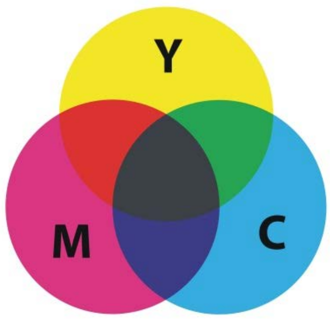


Image Sensors





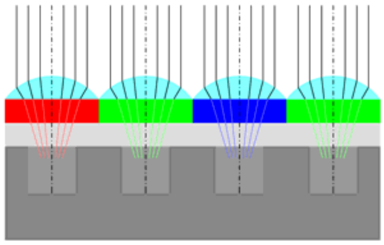
There are different ways to express colours. Additive systems start on black (total darkness) and then adds colour. Red, blue and green lights all shine on the same spot at different intensities. If only the blue light is on (and red and green off) then the surface where the light is shining is blue. If blue is off, but red and green shine on full power, the surface is yellow. When all spots shine on maximum intensity, the surface is white. An additive system can express black and white. Black means all lights are out and white that all lights shine at maximum power. By varying the intensity of the three light sources, a full range of colours can be expressed. That is logical, because also the human eye functions according to this system. The additive system that is used in the sensors of digital cameras is RGB, which stands for Red, Green and Blue.

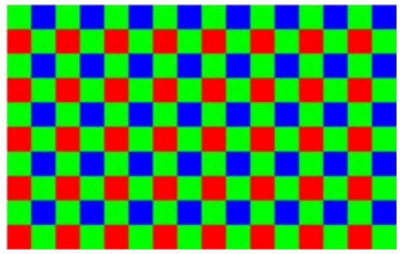
A subtractive system works the other way around. It starts with a white surface (such as a sheet of paper) and then adds pigments that absorb light. The pigments that are used in the CMYK system are cyan, magenta and yellow (the picture shows other pigments). This system is used in printers. Each pigment absorbs certain wavelengths. When white light shines on the sheet of paper, only the light that is not absorbed by the pigment is reflected and thus visible. A picture on paper takes the light away that is not supposed to be shown in the picture. The name subtractive thus means that light (or colour) is not added, but taken away.

In theory, when all light is taken away (all pigments are applied), the white paper should appear black. This is not the case. Applying equally big amounts of cyan, magenta and yellow would result in a dark grey shade. For that reason (and to allow more economic use of the other pigments) a black cartridge is added to the printer. This is the K in CMYK system (Cyan, Magenta, Yellow and blacK).

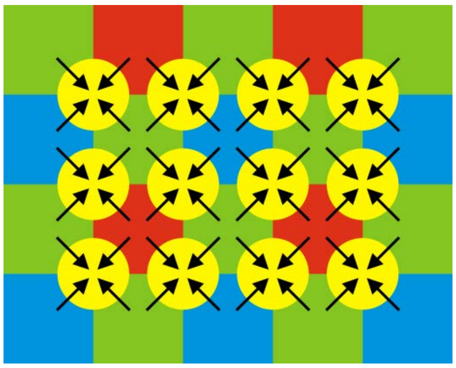
Images on the camera sensor and computer screen are expressed in RGB. But when printing a paper version of your picture, it will be expressed in CMYK. When using different colour systems, not all possible colours can be represented in all systems. The RGB system cannot show all colours that the human eye can see, and the CMYK system does not make it possible to show all colours that can be expressed in RGB. The sets of colours that can be represented or perceived (called gamut) overlap, but do not cover each other completely. Thus, when printing an image, the conversion often tries to find the closest colour it can but for some colours, the difference is noticeable. The difference can be reduced to some extent by using a colour correction profile for the printer.

Sensors are made up out of picture elements (or pixels). Each pixel is a light sensitive cell. There are red, green and blue cells which are often organised in what is called a Bayer matrix. The Bayer matrix has twice the number of green cells, compared to red and blue. To allow colour to be displayed, the pixel must not only "know" how bright it is, but also what colour it has. In most systems there are dedicated pixels for each colour, but there are exceptions such as Foveon X3 technology in which all pixels capture all three colours.





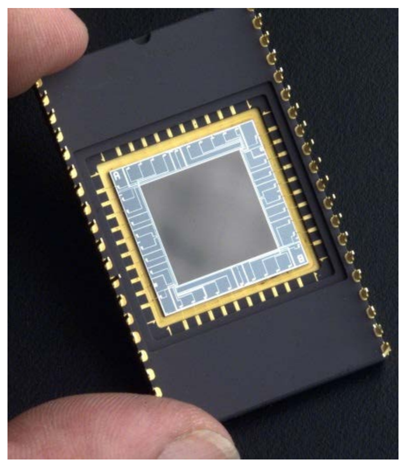
Normally all pixels have different colour filters. Each pixel captures red, blue or green light intensity. Light of other colours is blocked by the filter covering the cell.



The pixel now interpolates colour based on information from the surrounding cells. This might result in pixels assuming a wrong colour (colour artefacts and noise), which is especially the case in the low-light conditions that are typical to underwater images.

Each pixel needs a given number of photons (photon is the unit of light) to show a certain colour. The more photons that are needed to express a certain colour, the less the sensitivity for noise is. This means that pictures taken with an ISO100 setting are less sensitive to noise than pictures taken in ISO800.

The quantity of noise also depends on the type of the sensor, its size (the bigger the better) and its quality. All of these factors affect the price of a digital camera. There are two common types of image sensors. CCD (charge coupled device) sensors are the traditionally used type. The noise level is typically low with CCD, but they use more power than CMOS sensors and are slower in taking and transferring the picture.



CMOS (complementary metal oxide semiconductor) sensors have been in limited use in high-end digital cameras until significant improvements in their quality were achieved. They are easier and less expensive to manufacture, consume less power and capture images faster than most CCD sensors. CMOS sensors are equal to CCD sensors in image quality for photography.

Traditional CCD sensors work by accumulating light for each pixel, and then moving the picture towards the end of a row or column of pixels, where it is read one pixel or row at a time. CMOS sensors, on the other hand, do not have to move the contents of a pixel through other pixels in the same row/column because each pixel has some associated electronics.

The Role of the Light Sources

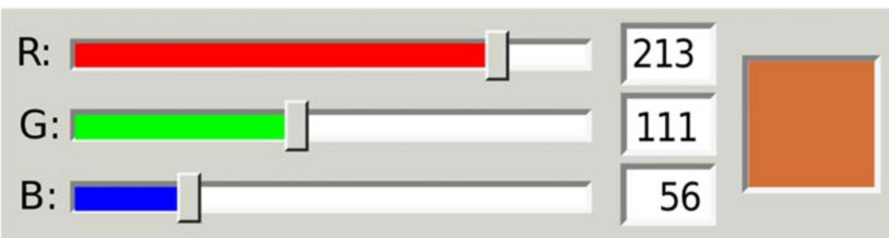
The colour of light is expressed in degrees Kelvin. Colour temperatures over 5,000K are called cool colours (bluish white), while lower colour temperatures (2,700–3,000 K) are called warm colours (yellowish white through red). It seems confusing, but it contrasts psychological perception with the pure physical meaning of temperature.

The colour of daylight while the sun is still relatively high in the sky varies from about 5,500 Kelvin to 6,500 Kelvin. At sunrise and sunset colour temperature ranges from 2,000 to 3,000 Kelvin. Inside buildings lower light temperatures are often used to create a relaxed atmosphere, while higher (colder) temperatures are used in offices to enhance concentration.

Stage lights used during concerts provide an (extreme) example of what happens if the colour of the source light changes. When yellow stage lights are used, everything appears yellow.

Light passing through water loses colours due to absorption. This changes the colour temperature. For the light from the sun, this is not a disadvantage. Water functions as a blue filter, allowing us to take pictures with a blue background. This gives the impression that we are underwater, which is exactly what we want. For the light coming from the strobe, this is different. The intent of using a strobe is to bring back the natural colours of the underwater environment. If the light source is too yellow (often the case with torches), too red or too blue, the desire to bring back natural colours will not be achieved.

With film cameras, the colour of the light the strobe had to be exactly right for compensating missing colours. Red light is lost while it penetrates the water on route from the strobe to the subject and then from the subject back to the lens. If you expected to be further away from a subject (one meter or more), it helped to start with some extra red in the light. If you stay close, the extra red light would be a disadvantage. This is why many wide-angle strobes have "warm" light with more red than normal. The warmer light is represented by a colour temperature of 4,800 to 5,000 Kelvin. For macro photography the strobe is used closer to the subject and the loss of red light will be less. Most macro strobes had a colour temperature from 5,300 to 5,500 Kelvin.

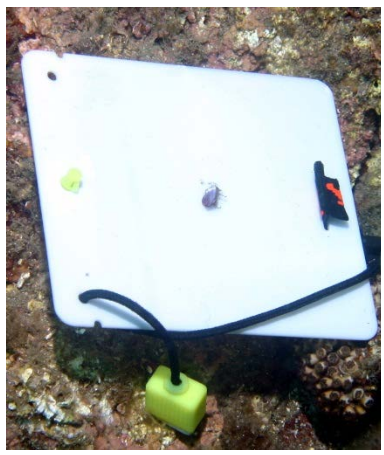


With digital cameras a strobe of exactly the right colour is less important, because of the white balancing options. White balancing is a correction for the light mixture arriving at the camera. A digital camera can register 256 shades of red, green and blue (0 up to 255). If all three colours are absent (0), the image is black. If all are 255 (maximum), the image is white. Every instance where red, green and blue all have the same value (for example 100, 100 and 100) is a shade of grey. If the values in the three channels differ, a colour will be expressed. If red were 255 and green and blue 0, then the image would be red. If both red and green are 255, but blue 0, then the image is yellow.

If white light were passed through a red filter, then blue and green would be filtered out (probably not completely, but for a large part). If the filtered light were to be used as the only light source to take a picture of a white sheet of paper, then the paper in the picture would appear to be red. The values in the RGB scale could then be something like: red 255, green 80 and blue 90. In reality, the sheet of paper is white (red, green and blue are all 255). White balancing means that we "tell" the camera that when green is measured 80; it should actually be displayed as 255 (and for blue 90 should be considered 255). We are thus stretching the 80 (or for blue 90) shades that are available when illuminating using a red filter to occupy the complete scale from 0 to 255. The result is that a white sheet of paper is now white in the picture.

There are different options for white balancing. The easiest is the use of one of the pre-set white balancing options. In many cases the "cloudy" setting gives reasonable results underwater. If your camera only offers the option of AWB and a range of pre-set white balancing options, then you should try each of the settings to find out which one results in the nicest pictures. The setting that should not be used underwater is the AWB (automatic white balancing). The automatic changes the setting for red, green and blue for each picture. This makes it completely unpredictable as to what a picture is going to look like. The pre-settings can approach natural colours, but cannot assure accuracy.

White balancing is not done at the sensor of the camera. The sensor captures an image which is passed on to the software installed in the camera. Within this software, corrections (such as white balancing) are done before storing the image on the memory card. Probably the most accurate way to do white balancing is to not use the camera software, but to do the correction after the dive on a computer. To do that, all information captured by the sensor must be stored on the memory card. The format in which information from the sensor is transferred to the camera software is .raw. Most professional photographers store their pictures in RAW. All corrections are then done later at the computer. Often there is also an option to store pictures both in RAW (image sensor data) and in JPEG (the picture corrected by the camera software).



Pictures in RAW are substantially bigger in file size than pictures that have already been transferred to JPEG. During the transfer all data that is not necessary to show the picture is JPEG is discarded. This makes a JPEG file less suitable for later corrections to the image.

If you take pictures in RAW, you should work in series. When arriving at a site where you want to take pictures, you should take a picture of a white slate (if possible with some colourful fields for verification) in the direction in which you plan to make images from the underwater world. Then take your pictures. When changing depth or your orientation to the sun, you should again start with a picture of a white slate. After the dive you do the corrections. Start with adjusting the colours on the picture with the white slate. Most programmes for treating RAW pictures then allow you to apply those corrections to the rest of the series. Repeat the procedure for all pictures of the white slate and subsequent series.

The same procedure can also be done on better digital cameras. You take a picture of a white surface and then "tell" the camera to adjust the white balancing based on the white surface in that picture. This allows you to store your pictures in JPEG and have them ready for use immediately after the dive (some cameras allow you to store the same pictures in RAW simultaneously). This is called custom or manual white balancing. Your first take a picture and then tell the camera to do adjustments based on that picture.

Not all cameras allow custom white balancing of a picture that you have just taken. Many cameras only permit a "real time procedure". This means that you point the camera at something white and then tell the camera to adjust the white balancing. This procedure will not work with strobe light. The flash is too short. If custom white balancing must be done in real-time, rather than on a picture that was already taken, compensating for the colour of the light from the strobe is not possible. The procedure does work fine for those who use a torch as external light source, rather than a strobe.

Strobes

The choice of a digital underwater camera is to a large extent guided by desires for options with respect to the strobe. A strobe should not be too close to the lens. A strobe flashing in the direction the picture is taken can result in a picture so full of back-scatter that it gives the impression it was taken in a snow storm. This problem can only be solved by using an external strobe.

Digital cameras cannot (directly) use the traditional TTL (Through The Lens) protocol. Traditional TTL underwater strobes are not compatible with digital protocols. Traditional TTL uses a light sensitive cell that captures the light that is reflected by a film. Image sensors hardly reflect light, which makes it impossible to make use of the traditional system. Protocols for digital cameras have names such as E-TTL, D-TTL or i-TTL. They measure the required light intensity before you take the picture and not during the exposure. Mostly the TTL sensor does not measure through the lens (as the name suggests), but is located beside the lens.

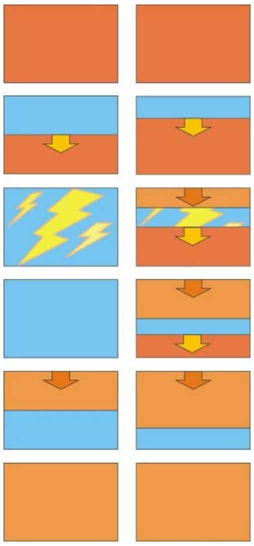
Smaller digital cameras and their housings often do not have a connection for an external strobe and can only be used with a slave. A slave strobe flashes the moment the flash from another strobe is detected. For that purpose, the internal strobe of the camera is used to activate the external strobe. This can be done without a cable, but that comes with a high risk of misfiring. This is why these strobes are connected via fibre-optic cable to make sure that the sensor of the slave registers the flash from the internal strobe. The sensor from the fibre-optic cable is placed in front of the internal strobe in the camera. To allow removing the sensor, it is usually fitted with Velcro.

Most digital cameras use a pre-flash to measure the available light and adapt the settings of the camera to achieve a correct exposure. Some cameras will deactivate the pre-flash in manual mode (but not all). Traditional slave strobes are not adapted to this and cannot be used with such a camera. They would flash with the pre-flash and would not be re-charged in time to synchronize with the flash that is fired to take the picture. This is the reason why there are special strobes for digital cameras (sometimes mistakenly called digital strobes).

Slave strobes for digital photography are either able to fire multiple flashes within a fraction of a second or they can be set to ignore a flash. They will only synchronize with the flash used to take the picture. The main problem with a slave strobe (compared to a TTL) is that the camera does not know it is there. To the camera, the flash when the picture is taken comes as a surprise. Therefore the camera does not take the extra light into account when altering the settings of the camera. The photographer needs to take precautions to prevent overexposed pictures. This is best done by taking pictures in manual mode, or another setting that allows the photographer to set the aperture.

Another consideration with respect to the use of a strobe is if the camera electronically controls the shutter speed, or if a mechanical shutter mechanism is used. A mechanical shutter mechanism makes the synchronization speed of a camera important.

Mechanical shutter mechanisms have two “curtains”. When you take a picture, the first curtain opens. The strobe is synchronised to flash the moment the first curtain is completely open (the row to the left). This is necessary, because the strobe flashes only momentarily. If the strobe were to fire too soon, only a part of the picture (the part that is open at the moment the strobes fires) will be illuminated by the light from the strobe.



At some point the shutter speed will exceed the speed with which the curtains move. In that case the second curtain starts to fall before the first curtain is completely open (the row to the right). In that case a stripe of light moves over the film or image sensor. You could compare this with a scanner. Different parts of the picture are exposed at a slightly different moment (in fractions of seconds). Now it does not really matter when the strobe fires. It will always illuminate only a part of the picture. The shutter speed is too fast to use a strobe.

The synchronization speed is the fastest speed that offers a moment in which the camera is completely open, which allows the flash from the strobe to illuminate the complete picture. You can use a strobe at slower speeds, but not at faster shutter speeds. It depends on the speed with which the curtains move and thus on the quality of the camera. The faster the synchronization speed, the more choice you have for shutter speeds when using a strobe. Electronically activated image sensors do not use mechanical curtains. These allow the use of a strobe at high speed. Most digital cameras have electronically activated image sensors. There are several criteria you should take into consideration when selecting a strobe.

The colour of the light is already discussed in previous sections. The further you go away from the subject, the greater the need to add some extra red to the light. This is why strobes used at short distances for macro and close-up photography should have a different colour than strobes used at greater distances. Short distance is in the range from 10 to 50 centimetres. When we speak of greater distance, we are talking of 1 meter or a little more. Strobes used at short distance should ideally have a colour temperature from 5,300 to 5,600 Kelvin and strobes that are used for a distance of around 1 meter should have a colour temperature of 4,800 to 5,000 Kelvin. Of course it is possible to adapt to a different colour of light via white balancing, but that solution is not ideal.

First of all, the correction reduces the amount of shades of a colour that can be expressed. With white balancing, a lack of red, green or blue is compensated by stretching the available shades (for example 100), over the complete range from 0 to 255. After stretching, the amount of shades that can be expressed is still only 100. The limited number of shades (100) is only assigned another value. Stretching will thus reduce contrast in your pictures. The second reason is the colour of the water behind your subject. If the subject itself requires massive corrections in white balancing because of a non-adapted colour of the artificial light source, the adjustments will also affect the way the colour of the water is expressed in your pictures. The closer you are to the ideal colour of light for your external light source, the easier it will be to achieve pictures with natural colours for all aspects (the subject and the background).

Most strobes need several seconds to reload after a flash. Especially when you are bracketing (taking more than one picture of the same subject with different settings on the camera) it is annoying to have to wait too long for the strobe to be ready. The capacity in number of flashes was not a big issue in traditional photography of a maximum of 36 pictures or even less. A digital camera with a big memory card allows you to take several times that number of pictures on a single dive. When you use a digital camera, you might want to take a look at the maximum number of flashes your strobe can do before charging the batteries.

Depending on the way your strobe is connected to the camera, you might want or need different options for firing the strobe. A TTL option can help you in many circumstances, but not in all. Even if you have TTL communication between the camera and the strobe, you would still want an option to fire the strobe manually. The TTL firing option is limited to only one brand, unless the strobe supports multiple protocols. When connecting a strobe with the wrong TTL protocol, the manual mode could still function normally. If there is no communication between the strobe and the camera, you need a slave function to fire the strobe. When using the slave option, you need to see if the strobe can ignore pre-flashes, or if the strobe is able to generate a pre-flash and flash again a fraction of a second later.

The “cone” in which a strobe illuminates the subject of a picture varies. Many wide-angle strobes cover an area of about 105°, smaller strobes have a more narrow cone and cover a smaller area. The angle the strobe is covering should be slightly bigger than the angle of acceptance of the lens you are using. This means that the strobe is a limiting factor for the use of lenses. If your strobe covers a 90° angle, you cannot take pictures with a lens that has a 92° angle of acceptance.

It might be tempting to opt for a strobe with a wide cone, to have a strobe that offers the flexibility to use any lens you want. This comes with some inconveniences. The light from the flash is concentrated on a small area when leaving the strobe. The further away from the strobe, the more area the same quantity of light is illuminating. This means that the intensity of the light per cm^2 decreases with the distance it travels. Combined with the loss of intensity due to diffusion and absorption, the loss of light intensity is substantial even at short distances. A relatively small strobe with a concentrated beam can have the same Guide Number as a powerful strobe with a wide beam. Strobes with a wide angle are thus large and bulky. A larger angle also increases the risk of back-scatter.

The Guide Number of a strobe gives you an indication for the distance at which a strobe can be used with a given F/stop. Normally Guide Numbers are given for 100 ISO on land and can be expressed in feet or in meters. If the guide number is expressed in feet, you need to multiply it with 0.3 to find the metric Guide Number. The formula for the use of Guide Numbers is:

GN = F/stop x Strobe to Subject distance

Based on this, you can use the guide number to calculate the needed F/stop for a given distance from a subject, or you can use it to calculate the required distance for a given F/stop:

F/stop = GN / Strobe to Subject distance

Strobe to Subject distance = GN / F/stop

Note that the formula takes the distance from the strobe to the subject into account and not the distance from the camera to the subject. With an internal strobe the two would be the same, but with an external strobe there could be a substantial difference.

For the correct use of a strobe, the relationship between the distance, the F-stop and the Guide Number needs to be correct. When you change one factor (distance, F-stop or Guide Number) another factor needs to be changed as well to assure a correct exposure. Metered strobes and TTL strobes automatically adapt the GN to the light needed for the given distance and F-stop by measuring the light falling on a sensor and communicating this to the strobe. The strobe will limit the output based on this information.

When a manual strobe is used, the guide number is a fixed value (if the strobe does not allow you to limit the intensity of the flash). In this case you need to make calculations for distance/F-stop options. As it would be difficult to do these calculations underwater, it is a good idea to make a chart with some possible settings and take it with you when taking underwater pictures.

Example: You have a strobe with a Guide Number 4 at 100 ISO underwater. This could result in the following options when taking pictures underwater.

- 4/F5.6 = 0.7 meters
- 4/F8 = 0.5 meters
- 4/F11 = 0.35 meters
- 4/F16 = 0.25 meters

A potential problem with guide numbers is that the manufacturer only gives a value for land. One of the reasons for that is that the visibility has an influence on the Guide Number, which could make underwater guide numbers rather inaccurate. This means that you must first find out the guide number for underwater for a given strobe and the average local diving conditions. Some recommend dividing the land Guide Number by three. A more accurate way would be to take a series of pictures in which all factors but one is kept the same. You could opt for F/8 at exactly 1 metre distance and take a picture for every Guide Number on the strobe. This would have to be done in an environment where there is no (or only very little) ambient light). This will give you a series in which one picture is best.

With that setting as a basis, you can calculate other settings based on that Guide Number. For example – moving from 100 ISO to 400 ISO doubles the GN. If the sensor only gets one step faster (200 ISO) you have to multiply the GN with 1.4 and when you set an ISO that is one step slower, you have to multiply the GN with 0.7. The Guide Number doubles when the film is four times as fast and the Guide Number is reduced to half when the film is four times slower.

100 ISO – 4 200 ISO – 5.6 400 ISO – 8 800 ISO – 11 1600 ISO – 16

For the Guide Number the shutter speed has no relevance. A strobe flashes only a very short moment. If the camera is open longer than the duration of the flash, this does not influence the amount of flashlight reflected – during the extra time there is no more flashlight. This means that the shutter speed is used to control the amount of ambient light falling in the camera, while the distance and the F-stop are used to control the amount of flashlight falling in the camera. All calculations with Guide Numbers ignore the shutter speed, because there is no need for taking that into consideration.

Automatic (or metered) strobes that are connected to the camera receive the information on the aperture that is set directly from the camera. If a metered strobe is used via a fibre optic cable, then the photographer must set the strobe for the same F/stop as the camera. Normally automatics are only used when a picture is to be taken without delay. As the automatics from the camera, also the sensor of the strobe will want to achieve 18% reflectiveness. Darker subjects are likely to be overexposed and brighter subjects underexposed.

With manual settings, the exposure is always correct as long as the distance was correctly measured and the F/stop and ISO are set that correspond with the selected Guide Number. It would thus be an advantage if a strobe offers the option of manual settings, as well as automatic. The strobe to the left in the picture only has manual settings (see the Guide Number setting to the left). The second strobe is a TTL strobe that connects to the camera via a cable and does not offer the possibility of manual settings (other than “on” which is full power). The third strobe is an automatic strobe that requires a manufacturer specified F/stop and can only be used with that setting. The last strobe to the right is an automatic strobe via fibre optic cable on which the F/stop must be set for the same value as on the camera (see the setting at the right). There is no option for manual settings. Other than the models shown, there are several strobes on the market that offer multiple settings.

If you choose for a strobe with manual settings, you should take a look at the aperture that can be set on your camera. It is more often the case that a strobe is too powerful than being confronted with a situation in which the strobe is not powerful enough. If the smallest F/stop that can be set on the camera were to be F/5.6 and if your strobe were to be GN3 as the lowest Guide Number, then you could not take any pictures at a lesser distance than about 50 centimetres. If you like macro photography, you should select a combination of camera and strobe that allows you to go as close as 20 centimetres. This requires very low Guide Numbers, or a camera that can be set for a small aperture, such as F/16.

Preparation & Taking Pictures

Before actually getting into the water to take pictures, there are some preparations to be done. These concern yourself, the data that are needed and the camera equipment. Photography places high demands on the diver. Control over buoyancy must be very good (and that in different body positions). Considerations for the various settings of the camera and strobe, as well as estimating the correct distance and deciding on angles comes with a high cognitive demand.

Photography dives must be well prepared. This chapter addresses several aspects of that preparation. It starts with some input on your personal skills for buoyancy and trim. You will find that the camera and strobe influence your positioning in the water, which requires additional skills to keep control over positioning. The next part addresses preparation of data. Mathematics with guide numbers and aperture results in distances expressed in centimetres and metres. Such distances must be converted into more practical manners to measure distance underwater. The last parts of this chapter concern the preparation of the camera equipment and advise for taking pictures.

Preparing Yourself

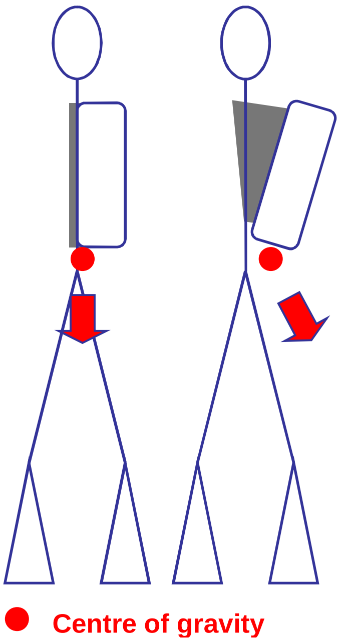
If a part of a picture is blurred, then this part of the picture has either moved during the time that the shutter of the camera was open, or is out of focus. If the entire picture is blurred, then this is often an indication that the camera has moved during the time that the shutter was open. It should be obvious that the risk of such movement is greater with slow shutter speeds. The risk also increases with a longer focal point of the lens. Wide angle lenses are a lot less sensitive to camera movement then telephoto/macro lenses.

The shutter speed is decisive for the colour of the water in the background of the picture. Sometimes we will want to make use of a slower shutter speed to capture an azure blue background. It is also likely that we will want to use a lens with a long focal length from time to time, especially those who like to take macro pictures. In both cases you must take extra care of your stability underwater. When you move, the camera moves. This is exactly what we want to avoid.

The first thing to look at is the use of your "trigger finger". Many people have a tendency to move all fingers when they bend their index. Moving the other fingers could move the camera. This movement will blur the picture as well as influence the framing of the picture. You can consider keeping the camera steady with two hands, or train yourself to use the index without moving the other fingers.

Next to "pulling the camera down" when taking a picture, it is also a challenge to prevent movement of your arms or your entire body. On land you can assume a stable position with both legs on the ground and your upper arms in contact with your chest. Underwater you are hovering in front of your subject. This makes it harder to assume a stable position. If you are not stable, movement of arms and body will translate in camera movement.

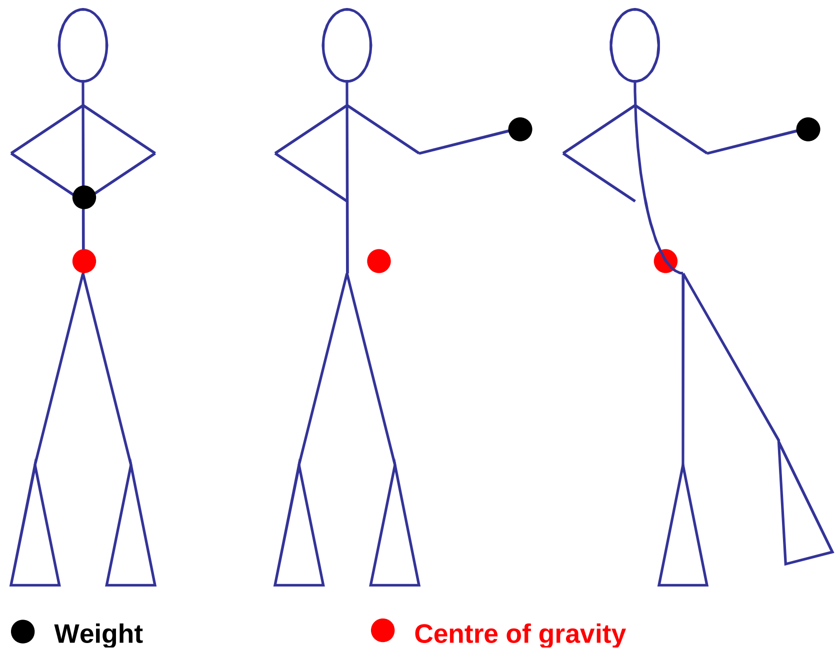
Using extra weights to assume a stable position on the bottom is not a solution. Apart from safety and environmental considerations, it will limit your options for taking a picture and it will cause silt on the bottom to be stirred. Bottom contact will substantially increase the risk of backscatter. Your best option is to train yourself until you can assume a stable position in mid-water under any angle needed to take a picture. This involves an adequate choice and preparation of diving equipment, the use of your spinal cord and a complete control over your breathing.



Your equipment must allow you to hover in both a vertical and horizontal (face down) positions. This means that the centre of gravity must be more or less in the centre of your body. If the weight of your cylinder is pulling you in a face-up position, then the equipment must be adjusted before taking pictures underwater. If a cylinder is pulling you in a face-up position, then the cylinder is probably too heavy or has too big a diameter (this is often the case with short 12 litre cylinders).

A more common reason is that the BCD is too big. This allows the cylinder to lose contact with your back, which brings the weight of the cylinder behind you. A last consideration is the distribution of weights. It might take some time and work to adjust your equipment, but it is worth your while. Any movement needed to maintain a position that allows you to take a picture can translate into movement of the camera.

The next step with respect to the equipment is to see if you can assume different positions underwater without creating a need to move with your arms or legs to maintain that position. You will find that a dry suit is ideal for that. The air in the suit will move to the highest point, which will stabilize you in a position of your choice. As a result you can hover horizontally with the head down, head up, on your left, on your right, etc.



Assuming a position of your choice in mid water does not only depend on your equipment. It also depends on your ability to work with your spinal cord and the positioning of your legs. You can train yourself by taking a 2kg weight in your hands and, while hovering, stretch the arm with the weight in different directions. The idea is to keep your upper body in the same position while changing the direction of the weight. You do this by compensating with your bodyweight. By bending your spinal cord in the opposite direction, you can keep the centre of gravity in the centre of your body. It will take some work to get the feeling for the use of your spinal cord, but it will soon become second nature.

A last step to control your position in the water and to prevent movement of your body and the camera is control over your breathing. In general we say that you become slightly negatively buoyant when you exhale and slightly positively buoyant when you inhale. You would thus expect to descend when you exhale and ascend when you inhale. The part on the altered buoyancy is completely true, but this is not the case for the resulting movement. The movement comes with delay and you must take this delay into account when you want to stabilize your position in the water. Also this will soon become second nature, but initially you need to invest some time to practise.

When you descend after having exhaled, you will not immediately ascend after inhaling. The downward movement will continue, gradually slowing down until the downward movement stops and then starting an upward movement which will start very slow and become gradually faster. The idea is to make use of the delay before movement starts. You inhale and then wait for the moment the downward movement stops. At that moment (before any upward movement starts) you exhale again. It will then take a moment before a downward movement starts. When you sense that it is about to start, you inhale again. After you have inhaled and exhaled at exactly at the right moment for 4 or 5 breaths, you can take up a normal breathing. You will then find that your stable position will be maintained.

Preparing the Data

With a digital camera it is very tempting to just go out and shoot pictures. You can delete what is not good and with computer software you can “bring lost colours back” and correctly expose underexposed or overexposed pictures. You can shoot more than a hundred pictures on a single dive and just hope for the best. Unfortunately a corrected picture can never have the same quality as a picture that was correctly exposed.

The problem lies in the number of shades of red, green and blue (maximum 256) that can be expressed. If a pictures in overexposed; only part of the scale possible values are used.

This is illustrated in the series of pictures above. The picture in the middle has an acceptable exposure. To the left, the same subject is underexposed and to the right overexposed. Both on cameras and computer software, there is an option to show a histogram. The histogram shows the average values of all the shades in the red, green and blue channel (some cameras also allow the display of all the individual channels). The histogram expresses the shades from 0 to 255 from the left to the right. The vertical values express the level of exposure in each of the shades. Both in the underexposed and the overexposed picture, only a small part of the shades show an exposure value.

An exposure correction would involve stretching the few values we have over the entire length of the scale from 0 to 255. This would correct the exposure, but we cannot add what is not there. If only 80 shades show any exposure, then stretching them over the entire scale will not increase the number of shades, it will just move them to another location. Although the resulting picture could be correctly exposed, it could never show the level of detail of a picture that was correctly exposed. Different nuances and shades in the picture cannot be expressed.

Compared to traditional photography, digital photography presents an essential difference. In traditional photography, it was necessary that both exposure and white balance were reasonably correct in the original picture. The possibilities for adjustment were limited. Taking digital pictures in JPEG is similar, but the options for adjustment are bigger than they were in traditional photography. Photography in RAW is fundamentally different. Pictures are taken with their potential in mind. Any corrections can be done later, as long as the information needed is present in the file. A picture with a full range (0 through 255) of shades has more potential than a picture in which only part of the scale shows an exposure value. Obviously the histogram can only reflect what was in the picture. In a picture of a green tree against a blue sky, you expect the red histogram line to show only few exposure values (if any at all).

This means that the preparation for a dive (if a manual strobe is used) involves data that can aid in achieving a correct exposure. The first thing you need is the guide number from your strobe underwater. This will give you a range of distances, strobe settings and F-stops that allow your subject to be correctly exposed. With the guide number you can make a full table of settings that would result in a correct exposure. Starting with an underwater guide number at ISO 100, you can also calculate values for other ISO settings if you wish. This example uses the formulas from the previous chapter in order to create a table for a strobe with three settings (GN 2.5, GN 3.5 and GN 5).

ISO 100 – strobe with guide number 2.5, 3.5 and 5 – strobe to subject distance in meters									
	F/2	F/2.8	F/4	F/5.6	F/8	F/11	F/16	F/22	F/32
GN5	2.50	1.79	1.25	0.89	0.63	0.45	0.31	0.23	0.16
GN3.5	1.77	1.26	0.88	0.63	0.44	0.32	0.22	0.16	0.11
GN2.5	1.25	0.89	0.63	0.45	0.31	0.23	0.16	0.11	0.08

The next step would be to rule out all impossible settings. Delete all distances bigger than one and a half metre (out of range for underwater photography), distances less than the minimum distance on which the camera can focus, as well as aperture settings that are not available on the camera. Assuming that the minimum distance for focussing would be 40 centimetres and that the smallest aperture would be F/8, the table can be reduced to possible settings only:

ISO 100 – strobe with guide number 2.5, 3.5 and 5 – strobe to subject distance in meters									
	F/2	F/2.8	F/4	F/5.6	F/8	F/11	F/16	F/22	F/32
GN5			1.25	0.89	0.63				
GN3.5		1.26	0.88	0.63	0.44				
GN2.5	1.25	0.89	0.63	0.45					

The guide number calculation works rather accurately for distances of 50cm and further, but at closer range the filtering of the water is reduced, which results in a risk of overexposure. The varying filtering of water has another important consequence. The calculations are rather exact, but in reality (while taking pictures) they should be seen as approximate values. There is tolerance to move closer or further away.

Unfortunately, a list like the example above is of little use for an actual photo dive. Even with tolerance, a value such as 88 centimetres is meaningless while underwater. To measure distance underwater, you need relative values, rather than the absolute distance in centimetres. Underwater you could stretch out your arm to measure the distance to your subject. For greater distances you could point the camera with strobe in front of you. Expressing distances underwater as “at an arm’s length” or “can just be touched with the strobe” is much more useful than a numeric value.

In reality, creating a list of possible combinations of guide number and aperture would therefore begin with distance and aperture rather than guide number and aperture. Experiment with different ways to measure distance underwater and ask your buddy to measure the distance in centimetres. Then multiply the distances with available apertures to see which guide numbers would be required. If an arm’s length would bring the strobe 50 centimetres from the subject and you have an F/8 setting available on the camera, then the required guide number would be GN4. Now look on the strobe for the GN closest to 4 (for example 3) and write on your list – arm’s length at F/8 = GN4. That the actual distance is 50 centimetres is of no interest while underwater. In this way you can create a (short) list of settings that you have available during your dive.

Guide numbers printed on strobes are not always accurate. It might be good to verify them before actually going on your photography dives. To do this, take several pictures in manual mode of the same subject in an environment with only little ambient light (a partly covered pool for example). Measure the distance to assure consistency. Take a picture with the calculated combination of aperture and guide number and then with values above and below. Vary only the aperture or only the guide number. Keep the other value constant. Remember that any automatic functions in a dark environment (such as a covered pool) will change to capture more light. If you do this test, then you have to set the camera on manual and select a reasonably fast shutter speed (for example 1/100 of a second).

Now compare the colours in the underwater pictures with the colour of the same objects on land. Select the picture which is closest to the colours on land. If this is the picture that was taken with the settings as printed on the strobe, no corrections are needed. But if you find that a picture with another setting gives a better result, then you must alter all values.

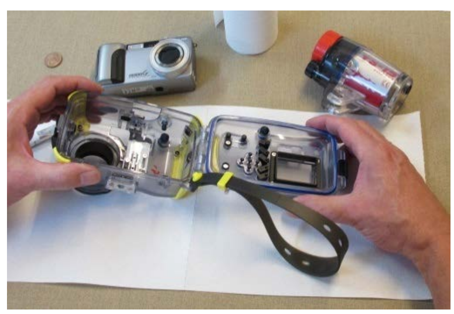
Preparing the Equipment

If a fibre optic cable is used, avoid light from the internal strobe illuminating the water in front of the camera. This can be achieved by making a mask. In the pictures, the making of such a mask is illustrated. It is an advantage to work with velcro™ because this allows you to remove the mask when it is not needed, or to dry the camera.

The electronics of an underwater camera and strobe are very sensitive to water. You must to prepare the equipment with appropriate care to avoid water getting into the system. To seal the air-filled space in the camera and strobe from the environment, O-rings are used. An O-ring seals to some extent when it is in place under ambient pressure, but when the ambient pressure increases, the O-ring is pushed into its optimal position. When entering the water, you should hold the camera above water until it is possible to descend the equipment a full arm's length. The worst place for a camera is at the surface, just in the water but not deep enough to benefit from the water pressure to push the O-ring in place.

It is recommended to prepare a camera well before the dive to make sure that you are not in a hurry, to follow your own "standardized" procedure and to work in a clean area. Give your camera the needed care and it will work for a long time. The care for the camera needs to be done before every dive.

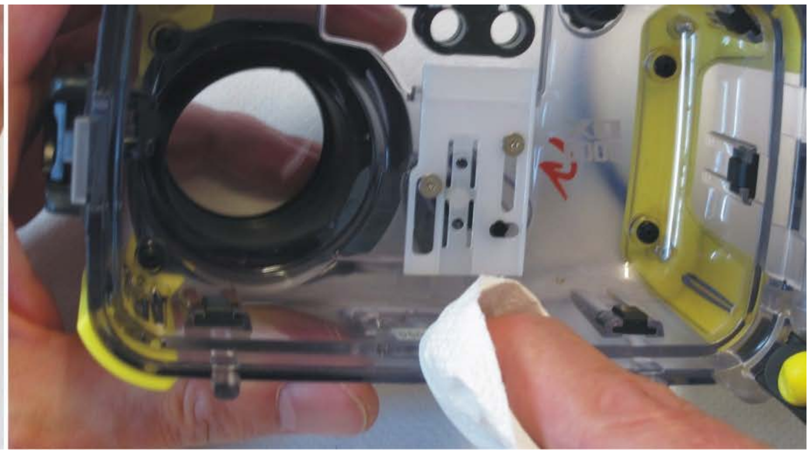
Opening the camera or housing can be a challenge if the atmospheric pressure has changed since the last time you closed it. There is no problem if the previous atmospheric pressure was higher, but when it was lower, you need to apply some force to open the camera or housing. Do not apply force to the mechanism used to lock the camera or housing (left picture) because it is not made for that. You can take a coin or a small piece of plastic and make a turning movement to lift up the back plate (right picture).



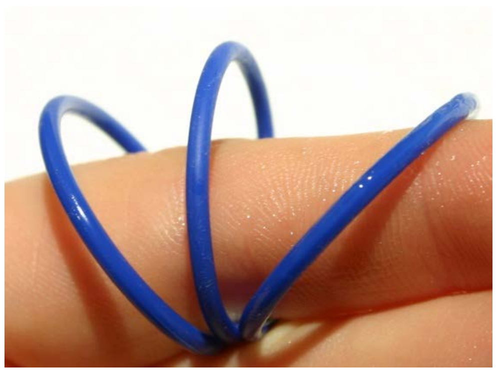
You also need to make sure that you are working on a clean surface. A good way to do this is to use some paper tissue. The white background allows you to see a hair, sand and other risk factors immediately.

You need to clean your hands and dry yourself after a dive to prevent water dripping on the camera. You might want to make your hair wet or wear a cap to prevent hairs from falling on the camera or housing.

As a first step you should do a visual inspection. Many housings are made out of plastic, so there can be a crack or scratches. You should also take a look at all the buttons to verify that they move smoothly. When this is not the case, it is likely that the O-ring sealing the knob is blocking the movement and that indicates that the O-ring will not seal anymore.

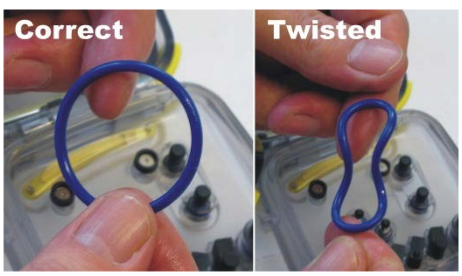



The next step is to remove the O-ring(s). To do this you can use some tissue. Exert light pressure on both sides of the O-ring and push the O-ring to one side. This will move the O-ring from its groove and allow you to grab it with your other hand. You can now clean all the surfaces that are in contact with the O-ring. The same procedure would apply to the strobe connection and battery compartment, if your equipment has these.



Then the O-ring itself must be cleaned to remove old grease and dirt. While doing that you should verify the condition of the O-ring. Look for scratches and check if the O-ring is of equal diameter for the entire length. If the O-ring was squeezed at a certain spot in the housing because of wrong placement, it will be flattened. In that case, it should not be used again. Make sure that the tissue you use to clean the O-ring does not leave any residue or fibres on it. Once the O-ring is cleaned, it needs to be greased again. There are different types of silicone grease. You should use the type that is recommended by the manufacturer.

Don't use too much silicone grease. In the picture, the O-ring to the right has too much grease, the one in the middle is dry and the O-ring to the left is greased correctly. The grease should be just enough to allow the O-ring to slide into place the moment the ambient pressure increases. Put some grease on a finger and then grease the O-ring until it is shiny.



Make sure the O-ring is not twisted when you put it in place and that it does not twist while you put it in place. Twisted O-rings are a common cause of flooding. Greasing an O-ring must be the last thing you do before putting it in place. Dust, sand and hairs stick to silicone grease. If you put it away for a moment to prepare something else, you have to start the cleaning of the O-ring all over again. Plan the moment you put grease on an O-ring appropriately.

Before putting the camera into the housing you need to check it. Make sure you have placed a memory card and that the batteries from the camera are completely charged. If needed, attach the strobe cable.

When you put the camera in the housing, you should pay attention to any turning knobs. Knobs that are just meant to push on a button are usually no problem, but knobs that function by turning usually need to be adjusted to the same setting as the setting of the camera in the housing. Otherwise they either will not function, or you will read the wrong information on the outside of the housing.

You also need to take precautions to prevent condensation in the housing. Moisture in the housing might condensate when immersed in water that is colder than the air temperature. This can be done with water absorbent chemicals (silica gel). Another method would be to blow dry air from a diving cylinder in the housing before closing it. You can also prepare the camera in a room with low humidity, such as a room with a working air conditioner. It does not really matter which method you select, but you need to do something. Condensation in front of the lens would otherwise ruin your pictures.

To prepare the strobe, you follow the same steps and care for the O-rings in the same manner. If you have a strobe connection, you need to take care that you don't spill silicone grease on the contacts. This could disturb the communication between the camera and strobe. In that case the strobe might misfire or the TTL circuit might not work.

Once the complete system is set up, you need to test it. Especially the communication between camera and strobe must be verified for proper functioning. It would be annoying to be underwater with a camera and strobe that do not communicate correctly or not at all. If the equipment works correctly, you should switch off the strobe and the camera to avoid draining the battery, especially if you prepare the camera the evening before the dive.

If the control light on the strobe of your digital camera is on, but the strobe does not fire when you take a picture, you can try to see if repositioning the sensor from the fibre-optic cable solves the problem. If this does not work, try firing the internal strobe directly in the sensor at the strobe, to see if the cause of the problem is within the strobe itself or in the fibre-optic cable.

Also check that the setting is correct and that the strobe is ignoring the pre-flash (if needed). The strobe should fire with the flash that is used to take the picture. Problems with the strobe or fibre-optic cable need to be solved before taking underwater pictures. If you use an automatic strobe (TTL or other), you need to check the electronic circuit. To do this, take two pictures. One shot of a bright surface with a large aperture and another of a dark surface with a small aperture. The time the strobe needs to recharge should be substantially longer for the picture from the dark surface.

Getting Started – Your First Experiences with Manual Photography

Training yourself in underwater photography takes some time. You apply the theory covered in the previous chapters while experimenting with different types of photography. In the beginning it is best to concentrate on one type of photography only and then progress to new challenges step-by-step.

Macro/Close-up Photography – Solids only

Macro photography is sometimes defined as taking pictures of an area that is no more than three times as big as the image sensor or film. It can be substantially smaller, but if it is bigger than three times the size of the film or image sensor, it becomes close-up photography. Others define macro as life-size or larger. No matter which definition you take, you are dealing with small subjects and take pictures at short distance.

The easiest subject would have only one plane. The subject and the background are "solid" and there is little difference in distance between the two. All light will be coming from the strobe (there is not water in the picture that requires ambient light). This means that the shutter speed can be set relatively fast (for example 1/100 of a second or even faster). In a normal situation, the strobe can be set for automatic. A normal situation would be that the subject combined with its surroundings would reflect approximately 18 per cent. A requirement would however be that there is sufficient ambient light for the autofocus to function.

A small aperture will provide enough depth-of-field to have both the subject and the background in focus. If you use a manual strobe, the choice for a small aperture may be mandatory. Even on its lowest setting, your strobe may not allow a guide number lower than 3. At short distance the lowest setting on the strobe can easily result in overexposure with a larger aperture. However, the guide number is not calculated from the lens to the subject, but from the strobe to the subject. Even if the distance from the lens to the subject is very small, the strobe will be at a greater distance.

Keep the strobe centred above the camera if you want to avoid strong shadows to the right or left of the subject, or hold the strobe to the side if you want shadows. You may have seen that macro strobes used on land go all the way around the lens. This is because strobes at short distance create very dark shadows. Just as on land, underwater a second strobe can be used to soften shadows. In that case the second strobe is placed on the right hand side of the camera and is set for a lower guide number. But, in some cases you will want to create a strong shadow for creative reasons (as in the picture shown). Aiming the strobe has a big influence on the picture.

With a digital camera you can also take this type of picture with a torch, rather than a strobe. Since the light of the strobe is of a different colour than sunlight, white balancing is necessary. This can be done after the dive on a computer (RAW) or during the dive by white balancing on a white slate before taking the picture (JPEG). A torch has the advantage that the autofocus of the camera has enough light (the light from a torch is not only available while taking the picture, but also before). If you want to use an automatic setting, use time priority (Tv). To avoid a blur picture due to movement, a relatively fast shutter speed is necessary. However, manual setting would be recommended.

The moment a subject is not reflecting the "normal" amount of light, the automatic functions of the camera and strobe start losing their value. If the subject is very bright (toward white) or very dark (toward black), automatic exposure such as a TTL strobe will cause a wrong exposure of the picture in an attempt to make a "normal" subject out of it.

When all settings are done manually, it is a good idea to make use of the possibilities bracketing has to offer. Especially in digital photography, where it does not really matter how many pictures you take of the same subject.

Not only can a lack of ambient light hinder the autofocus, but also the subject. In order to get a subject, such as shown in the picture, into focus it is best to use manual focusing (but not all cameras will offer that option). If you have to (or want to) use autofocusing, then you could hold a slate (or your hand) next to the subject at the correct focusing distance. Focus on that, keep the "hold focus" button pressed and then take the picture. The "hold focus" could be the shutter button itself. If it is, you have to push it half way and push all the way through when taking the picture. With neoprene gloves (or even with bare hands), this can be a challenge. Many cameras have a button on the back (to be pushed with the thumb) that serves the same purpose. You would have to refer to the instructions for use. In some cases the focus-lock is combined with an exposure lock. In that case any automatic settings would base the exposure on the back of your hand or the slate used for focussing, rather than on the subject (which in several cases could also be an advantage).

Macro/Close-up Photography – Mixed Light

Focussing can become a challenge when the subject is surrounded by water. With a centred subject, and the autofocus set for "spot" in the middle of the picture, it should work out fine. But not all subjects are located in the middle of the picture and perhaps you are waiting to for a fish to swim in the centre before pushing the button. The techniques described in the previous section can still be an option. In addition your camera may provide the option to define a spot (other than the centre) to focus on. The camera may also have an automated programme that analyses the picture and provides a suggestion where to focus.

The exposure of a mixed light picture (solids and water) is more challenging than for a picture with only solids. You must provide settings for two different exposures at the same time. Even when the subject combined with the colour of the surrounding water seem to be "normal" (18 per cent grey), an attempt to take a picture with automatic settings will very likely turn out to be incorrectly exposed. This is because the water does not reflect any light. All the light that does not hit on something solid will continue to travel until it is completely absorbed. This means that all reflected light comes from the subject. If the subject is small in relation to the blue (water) area in the picture, then the subject will have to reflect a lot of light to compensate for the darker part in the picture.

The basic rule is that the F/stop and strobe distance are for the subject and the angle toward the surface combined with the shutter speed is for the colour of the water. Remember that the amount of strobe light reflecting toward the camera is hardly affected by the shutter speed, but the amount of ambient light falling in the camera is. The strobe only flashes for a small fraction of a second, but the ambient light is there the entire time the lens is open.

The more ambient light you want to enter the camera, the slower a shutter speed you select. Of course there are limitations. The slower the shutter speed, the more you need to pay attention that you hold the camera steady. There is a certain tolerance for camera movement. You could say that the picture of the subject is taken the moment the strobe flashes and that the rest of the time the camera is open is just used to fill in the background colour. Of course this is not "completely true", but it might come close enough to the truth to create the little tolerance you need.

If you are taking a picture of this type, you could proceed by selecting an F/stop and strobe distance relationship that would correctly expose the subject. With the selected F/stop you could then point the camera "in the blue" under the same angle and in the same direction as you plan to take the picture. In that case the camera (in manual mode) will give you a shutter speed recommendation. Set the recommended shutter speed, aim the strobe and take the picture. In most cases this will give you the blue colour you would like to see in the background of your picture, but it depends on "what your camera considers normal". After your first dives with that camera you will know how much above or below the recommendation you should be to get exactly the colour of water you want.

If you are in a hurry and cannot follow a procedure in which you have to measure ambient light, you have two options. Either you set the shutter speed for an estimated value (for example 1/60 of a second), or you set the camera for Av mode. In Av mode, the colour of the water will vary depending how much of the picture (in percentage) is of the subject and how much of the picture is surrounding water. With an estimated shutter speed, the colour of the water will vary with the angle and direction of the picture. The more you aim toward the surface, the brighter the blue background will be.

In some cases you might prefer the water in the picture to be black in order to have a better contrast with the subject. In that case, you should set the shutter speed for the synchronization speed (if you use an SLR camera with mechanical shutter) or for a fast value (as fast as 1/1000 of a second. You should also opt for a strobe distance – F/stop combination with a relatively small lens opening. The angle under which you take the picture must be downward. How far downward depends on the angle of acceptance of the lens you use. The angle should not allow sunlight to fall into the lens.

A last thing to take care of is that there is “enough water” behind the subject. If the bottom is close, it will reflect strobe-light and that will be visible in the picture. Strobe light reflecting from the bottom and ambient light entering the lens will prevent the background from becoming completely black.

The basic rule for water in the background is that it either needs to be completely black or completely azure blue. If it is “almost black” it does not look good and too bright or too dark blue also makes a picture less attractive.

With the techniques described so far, you can take colourful pictures of good quality. There are limitations. Such a limitation is a situation in which your subject has a foreground and background at a different distance. If you still want the colours to appear in all aspects in the picture, difference in distances would require a different F/stop and strobe-distance relationship. In that case you will need two strobes of different force to get both the subject and the foreground correctly exposed. The strobes must now be aimed correctly to make sure the light of each falls on the intended part of the picture. A single strobe can only provide the correct amount of light for a single distance.

Wide-angle photography

In wide-angle photography, it is rather common that the picture is made up out of three planes. These are the subject, the foreground and the background. If this is the case, then you must consider the use of two strobes. Also keep in mind that the big angle of acceptance of a wide-angle lens imposes a position of the strobe high above the camera. Wide-angle photography is not just a matter of fitting a wide-angle lens to the camera. Strobe-arms must be exchanged for longer ones and you must verify that the light beam of the strobe covers everything in the picture.

The shutter speed and the angle toward the surface are used for the exposure of the background (the colour of the water). The main strobe is used for the main subject and the slave or secondary strobe is used for the foreground. The foreground is closer than the subject itself. This means that the slave or secondary strobe that is aimed at the foreground should be set for a lower guide number.

In wide-angle photography you need to pay a lot of attention to aiming the strobe. Because of the big angle of acceptance of the lens, there is only little tolerance. With a single strobe, the smallest tolerance is sideways as the picture is wider than it is high.

In wide-angle photography, you should stay relatively close to the subject. It is a good habit to set all camera controls for taking pictures at a distance of one meter and then to adjust from there when going slightly closer to or slightly further away from the subject. If you always return the aim of your strobes, your F/stop, and the distance settings to the same values, you are ready for snap-shots and with time you will get into the habit of adjusting the settings to another distance without a lot of thought. You will also find it easier to get into the habit of estimating distances when you always use the same distance as a basis to work from.

Once you have the correct distance to your subject, you should pay attention to the size of the subject in your viewfinder. After you have done an initial framing of the picture, you have to aim your strobes and set the camera controls. In wide angle photography a small difference in distance will cause a substantial change in the size of the subject in the viewfinder. When you know the relative size the subject should have in the viewfinder, this will allow you to maintain the correct distance from the subject without taking your eyes from the viewfinder.

You can ask your buddy to assist you with aiming the strobe(s). Because of the rather big distance between the camera and the strobe it is not always easy to aim the strobes correctly.

In wide-angle photography there is no challenge in getting the subject in focus. In many cases the depth of field will range from 30 or 40 centimetres to infinity. In addition the tolerance for camera movement is greater than with lenses with a longer focal length. You will find that virtually all pictures you take with wide-angle are in focus.

Due to the big angle of acceptance, the background will appear to be further away from the subject than it actually is. If you want a diver to appear in your picture behind a coral, the diver needs to be closer than you would initially think. A diver does not have to be far away to appear completely, including fins, in the picture. A diver just slightly further away will already appear half the size and from there on he will get smaller and smaller. This effect will also come into play when you take a picture of a diver with the face closer to the camera than the rest of the body. In that case the face will be out of proportion with respect to the rest of the body and the legs will appear to be endlessly long.

Index