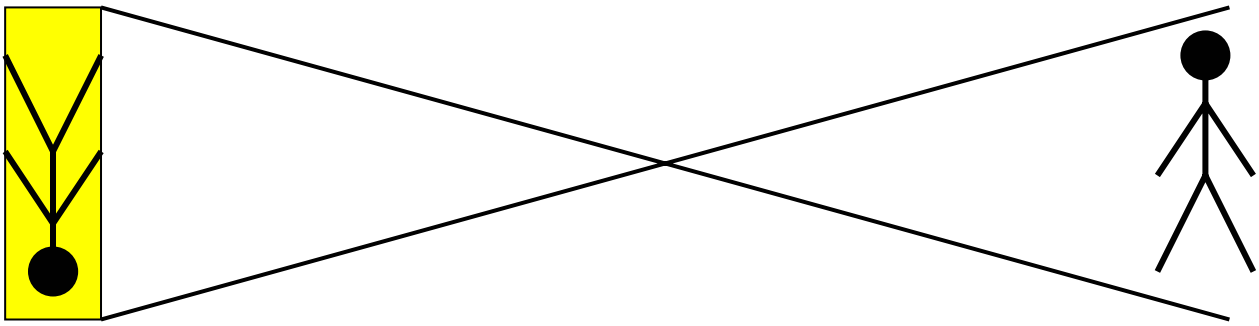
## Lenses

Different lenses are defined by their angle of acceptance (Fig. 1). As a human being sitting or standing at a certain location, we can see a specific area (when not moving our head or eyes). When 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 calling a lens a macro lens, which we will discuss later).

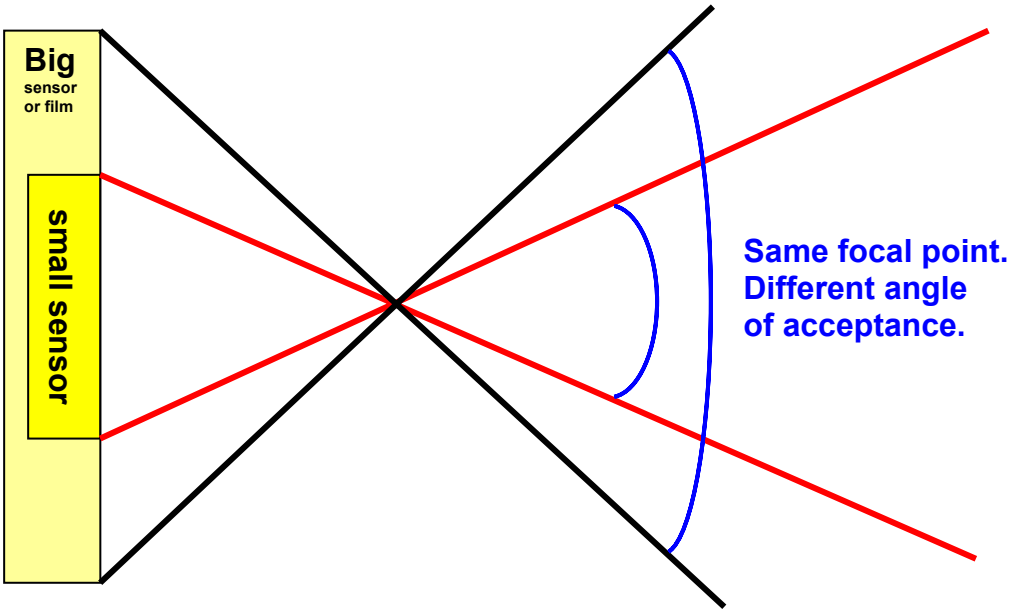
A lens can either have a fixed angle of acceptance or be a zoom lens. A zoom lens allows you to alter the angle of acceptance – without changing the position of the photographer we can increase or reduce the area that comes on the picture. With a fixed angle of acceptance, the photographer needs to approach the subject or move away from it to change what is getting in the picture.

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



*The light beams cross at the focal point. As a consequence, the image is projected upside down on the image sensor or film. The distance between the focal point and the light sensitive cell or the film defines the name of the lens.*

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", because the lens "sees" the same angle as the photographer. Unfortunately the difference in size of image sensor and film complicates things a bit. The same lens changes the angle of acceptance when the size of the image sensor or film changes.

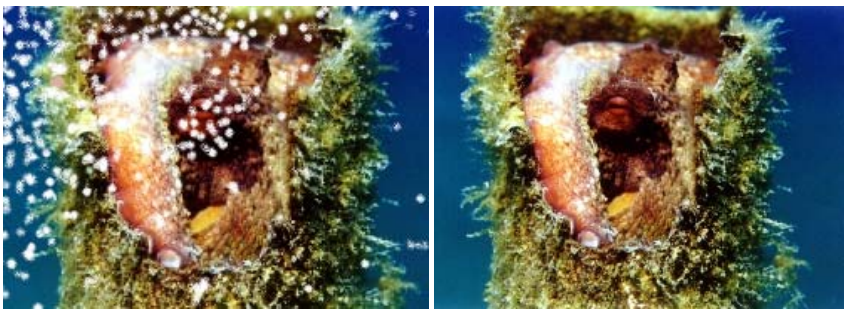



*The size of the image sensor or film and the focal length of the lens define the angle of acceptance.*

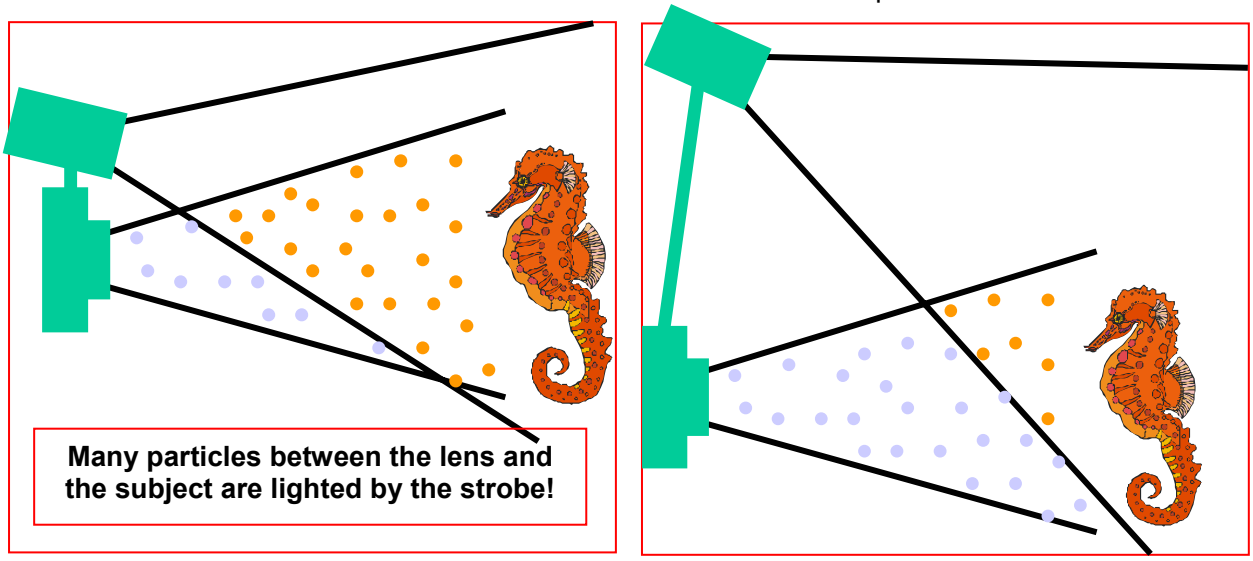
If there would be no diffusion, all light from the sun would travel in straight lines from the sun to the eye. We would see the sun as a white spot against a black background. In the atmosphere the light bumps into oxygen and nitrogen molecules. The wavelength of blue light is roughly the same as the diameter of an oxygen molecule, so it can not get past it and is scattered in another direction. Red light has a longer wavelength and goes right past the molecule, reaching 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 colors will be scattered and we see white, grey or black. In clear water we have a similar phenomenon, which allows us to take pictures with a blue background – even if the sky is not blue (clouded).

Because light is scattered in different directions, the diffusion (and also the 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 you need to open the aperture more and that the light of the strobe is getting more dominant.

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



The most disturbing consequence of diffusion is that some of the light is scattered back in the direction of their own source and, if too close, also in the direction of the lens. This light then appears as white spots in your pictures. In photography we refer to this phenomenon as “back-scatter”.

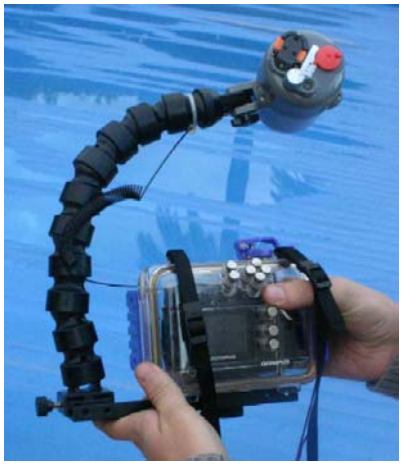



Back-scatter forces us as a photographer to aim the flashlight in a way that avoids lighting up the water between the lens and the subject of the photo and to pay attention to the angle under which particles are illuminated by the light from the strobe. Particles that are closer than the subject will 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 extra distance that the light has to travel through the water will decrease the intensity of the light. These particles that are further away are not (or hardly) disturbing in the picture. An internal strobe in a camera would light up all the water between the lens and the subject in the same angle the “camera is looking” and as a result cause maximum back-scatter.

## Considerations for the camera / strobe assembly

For traditional cameras there is an enormous choice of strobes. There is no problem in having the strobe communicate directly with the camera – either in manual mode or in TTL (automatic) mode. TTL measures the light from the strobe **T**hrough **T**he **L**ens while you take the picture and stops the strobe once there is enough light. There are also options to equip a camera with more than one strobe.

With digital cameras the subject of strobes is a bit more complicated. At the time of the writing of this book only a few commercially available camera–strobe combinations are able to communicate directly in a manner that allows the use of automatic external strobes under water.



The choice of a digital underwater camera is to a large extent directed by the wishes with respect to the strobe. As we read in chapter two, it is not a good idea to have the strobe too close to the lens. A strobe flashing in the same direction as 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. To limit this problem, an external strobe should be used.

Most digital cameras do not use the traditional TTL protocol. This means that the traditional TTL underwater strobes are not compatible with most digital protocols. Protocols used have names such as E-TTL (Canon), D-TTL (Nikon) or i-TTL (Fuji). They measure the needed light before you take the picture and not during the exposure. Some have successfully built external strobes for land photography in an underwater housing and some manufacturers have introduced some compatible underwater strobes for digital protocols. If you are looking for a digital camera in an underwater housing it is a good idea to first look at the availability of strobes and then decide on the camera.

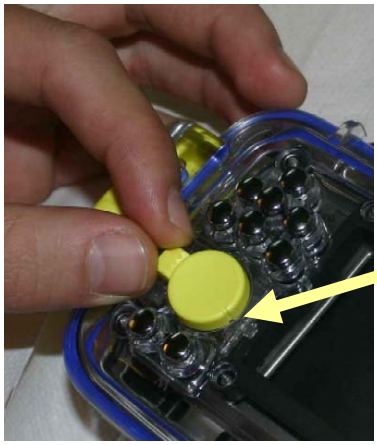
Smaller digital cameras and their housings do mostly not have a connection for an external strobe and can only be used with a slave. A slave strobe reacts by flashing the moment another strobe is flashing. This means that the internal strobe of the camera is used to activate the external strobe. This can be done without a cable, but that comes with the risk of misfiring. This is why most of these strobes are connected via fiber-optic cable to make sure that the sensor of the slave registers the flash from the internal strobe.

*The sensor from the fiber-optic cable is placed in front of the internal strobe in the camera. To allow removing the sensor, it is usually fitted with Velcro.*

Some digital cameras work with full-flash. This means that the intensity of a flash is always the same and that the correct exposure is assured by changing the camera settings or by changing the sensitivity of the image sensor. Others work with metered-flash, which means that the intensity of the flash is adapted to the light needed for a correct exposure, similar to TTL technology. Metered-flash technology will stop the internal flash the moment the correct exposure is reached.

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 normally no problem, but knobs that function by turning normally need to be adjusted to the same setting as the setting of the camera in the housing. Otherwise they either do not function, or you read the wrong information on the outside of the housing.

Before putting the camera in the housing you need to check it.



Make sure you have a fresh film or an empty memory card and that the batteries from the camera are completely charged. If needed, attach the strobe cable.

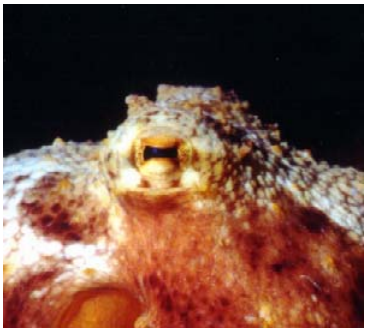
You also need to take precautions to prevent condensation in the housing. Moisture in the housing might condensate when immersed in water that is colder than the air temperature. This can be done with little bags with water absorbent chemicals. Another method would be to blow dry air from a diving cylinder 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.

For SLR housings there might be some additional considerations. An SLR (digital or not) allows you to look through lens via the viewfinder. To allow clear vision, a camera in a housing needs special optics in front of the viewfinder. The display of a digital SLR does not show the image before you take the picture, as the image sensor is obscured by the SLR mirror. The housing can also be built out of more than two elements. Each element is sealed with an o-ring that needs care before every dive. Using different elements makes it possible to equip the housing with different front ports. This way the same housing can be equipped for macro and for wide angle photography by placing a port that is adapted to the lens used.

To take care of 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.

The picture to the left comes from the book “Diving Equipment Functioning & Care” and communicates that the technician should fix the housing of the second stage and then work with the right hand. The impression of movement is possible thanks to a slow shutter speed. The opening (aperture) of the lens is reduced to assure that the correct amount of light reaches the film or image sensor. The small opening of the lens will also increase the depth of field. This means that the only blurred aspects in the picture are the moving tool and hand. This effect can hardly be achieved under water because of the use of a strobe. The flash from the strobe is so short that it will freeze most movement. If the lens is opened longer than the duration of the flash, this may not give the impression of movement, because the moment the strobe has fired will be dominant to the later exposure with ambient light only.

Longer shutter speeds can be used for another objective than capturing movement. It can be used to increase the amount of ambient light entering the lens and thus the color of water in the picture. As a basic rule, you use the distance/aperture relationship based on the guide number of the strobe to correctly expose the subject itself and then use the shutter speed to control the quantity of ambient light entering the lens, which allows you to alter the color of the water behind the subject. Set the desired aperture in manual mode with the strobe off and then measure the available light. The camera will give shutter speed recommendations which should be just right for a nice blue background of the picture. Set that shutter speed, put the strobe on again and take the picture.

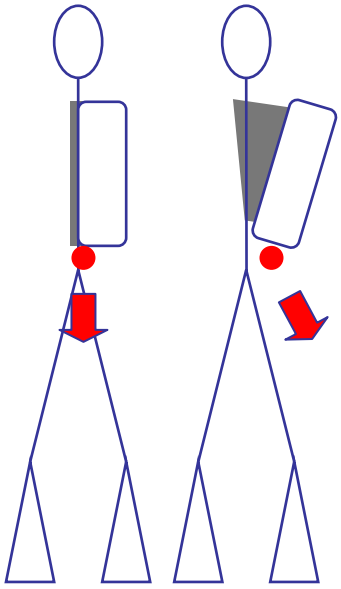


Achieving a black background is harder, as there are more factors involved. You should not allow any ambient light to enter the camera, as even the smallest quantity of light will change the black to become a dark shade of blue and the light of the strobe should have no surface to reflect on other than the subject of the picture. This means that you need a combination of a short shutter speed, a small opening of the lens and a downward angle away from the surface “into the blue” (the bottom must be far away not to reflect any strobe or ambient light). This limits this type of pictures to be taken either in mid water or at the edge of a drop-off or similar location.

To some extent, a black background can be achieved in macro and close up photography when not having a background “into the blue”. You will still need the combination of a fast shutter speed and a small opening of the lens, to prevent ambient light from playing a role in the picture. Since all light is now coming from the strobe, the black background can be achieved with the angle at which you aim the strobe at the subject, making sure that the shadow of the subject falls over the background of the picture.

Other than working with the color of the background, you can isolate the subject by blurring out the foreground, the background or both. This can be achieved with the depth of field. In the picture at the right this is done to indicate that a second person is looking at the lights on the back of the strobe while doing a “TTL test”, without allowing that person to dominate the picture and distracting from the real subject which is the person with the strobe.

Under water this can be an important tool because many creatures under water blend completely into their environment. When this “camouflage” prevents you from using contrasting colors to isolate the subject from its surroundings, you might be able to isolate the subject by using a bigger opening of the lens to limit the depth of field and placing the subject in the beginning or toward the end of the available depth of field. This may require manual focusing.

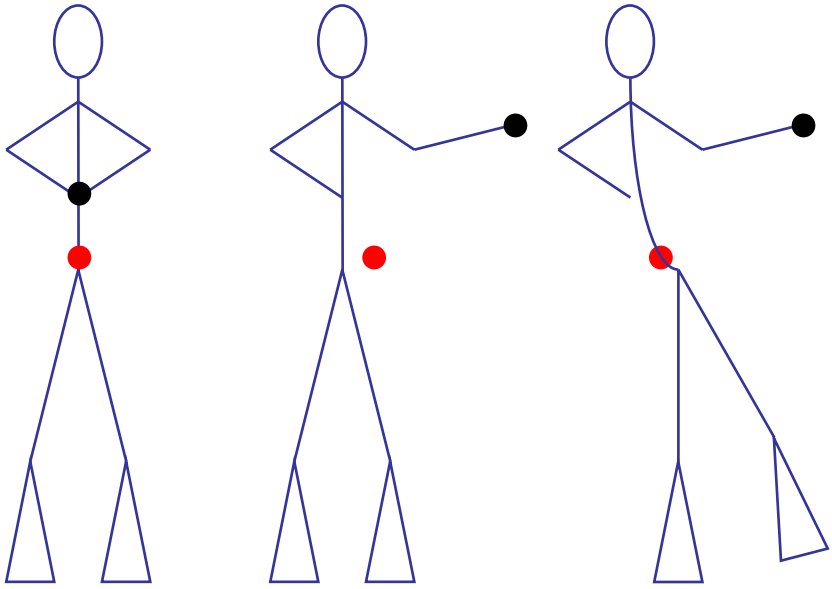


Center of gravity

Your equipment must allow you to hover in both a vertical and horizontal (face down) position. This means that the center of gravity must be more or less in the center of your body. If the weight of your cylinder is pulling you in a face-up position, then the equipment must be adjusted before engaging in underwater photography. If a cylinder is pulling you in a face-up position, it can be that the cylinder is too heavy or has too big a diameter (this is often the case with short 12 liter 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, because any movement needed to maintain the position of your choice to take a picture will translate in movement of your body and thus the potential risk of camera movement.

The next step with respect to the equipment is to look 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 always go to the highest point, which will stabilize you in the position of your choice. In that case you can hover horizontally with the head down, head up, on your left, on your right, etc. If the water is too warm for a dry suit, then you should opt for a BCD that has only limited obstructions for the air passing from one location to the other within the bladder.

Assuming a position of your choice in mid water does not only depend on your equipment, but also on working 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 your arm with the weight in different directions. The idea is to keep your upper body in the same position while changing the direction in which you stretch out the arm with the weight. You do this by compensating with your bodyweight. By bending your spinal cord in the opposite direction, you can keep the center of gravity in the center of your body. It will take some work to get the feeling for the use of your spinal cord, but those who use that technique during their dives do it as a second nature.



Weight Center of gravity

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 and thus descend when you exhale and ascend when you inhale. The part on the change in 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 become second nature soon, but initially you need to invest some time to practice and during that time you need to concentrate on inhaling and exhaling exactly at the right moment.