

# SHALLOW WATER BLACKOUT

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## What is shallow water blackout?

Shallow water blackout (more correctly termed '*breath hold hypoxia*' or '*apnoeic diving hypoxia*') gets its name because it occurs on the ascent, most commonly within the first 5 m (15-ft) of the surface. The blackout occurs quickly, insidiously and without warning. So how does it happen and what can free-divers do to minimise the risk?

Our body needs oxygen (O<sub>2</sub>) to survive. We have minimal O<sub>2</sub> stores and so need to breathe frequently. In very simplified terms, breathing-in supplies the cells of the body with fresh oxygen (from air), vital for cells to live and derive energy from metabolising our food. Breathing-out removes the waste products of carbon dioxide (CO<sub>2</sub>) and water vapour. For those chemistry minded, the process is explained by the simple equation:

C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> + 6O <sub>2</sub>	produces	6H <sub>2</sub> O + 6CO <sub>2</sub>	+ Energy
Food + oxygen	produces	water + carbon dioxide	+ Energy

This process is going on all the time and produces 'energy' for our cells, less when we are sleep and more when we are active. The more activity we do, the more O<sub>2</sub> we consume and the more CO<sub>2</sub> we produce. Our body adjusts to maintain a relatively constant environment without too much fluctuation in the levels of CO<sub>2</sub> and O<sub>2</sub>. As the CO<sub>2</sub> builds up, it stimulates more rapid breathing. It is the increased CO<sub>2</sub> that provides a more powerful stimulus to breathing, not the decreasing O<sub>2</sub>.

This can be clearly demonstrated when a person holds their breath on the surface. At the start of the breath hold the lungs are freshly filled with air and the body contains very little CO<sub>2</sub>. As the minutes progress, the O<sub>2</sub> in blood and tissues decreases (as it is used) and the CO<sub>2</sub> increases (as it is produced). Soon the urge to breathe is too strong to overcome and the person has to breathe.

The stimulus to breathe is due to the rising CO<sub>2</sub>, not the falling O<sub>2</sub>. Of course, some O<sub>2</sub> has been used but there is still plenty left at the time that breathing recommences. (If we actually analyse inspired and expired air we find it contains 21% O<sub>2</sub> as we breath it in from the surrounding and it still contains 16% as we breathe it out. This is why exhaled air can be used in expired air resuscitation of a non-breathing victim).

Now let's look at what happens during the breath hold of a free-dive.

There are three very important additional factors here. First, the practice of 'hyperventilation' at the surface prior to submerging, second, the effect that depth has on increasing the partial pressure of the available oxygen and third, the training that a free-diver undertakes.

Before a free-dive, the practice of 'hyperventilation' is common. This involves a series of rapid deep forced breaths, which is a very effective way of eliminating CO<sub>2</sub>. This abnormally low CO<sub>2</sub> effectively gives the diver extra time underwater before the CO<sub>2</sub> builds up to a level that causes the stimulus to breathe. As the dive progresses the O<sub>2</sub> is used up and CO<sub>2</sub> is produced. As it takes longer for the CO<sub>2</sub> to build up to a level which stimulates the urge to breathe, more O<sub>2</sub> has also been used up in the extended time. The levels of O<sub>2</sub> may become dangerously low. However, this is temporarily compensated for by the increasing partial pressure of oxygen (PO<sub>2</sub>) caused by the effect of depth. (E.g.: the PO<sub>2</sub> of O<sub>2</sub> at 10m/33ft will be double the PO<sub>2</sub> at the surface). This significance of this is that we need to have a minimum PO<sub>2</sub> in our blood to sustain life.

Just to understand the concept, think of PO<sub>2</sub> like a concentration. As a breath-hold diver descends, the lungs are compressed and the concentration of O<sub>2</sub> is therefore increased. Remember, over the duration of the dive, the breath hold diver is using up O<sub>2</sub> and producing CO<sub>2</sub>. The problem only arises as the diver ascends and the lungs re-expand, thus reducing that concentration-like effect. On ascent, the PO<sub>2</sub>, or O<sub>2</sub> concentration, can decrease to a point where it can no longer compensate for the low quantity of O<sub>2</sub> remaining in the lungs.

At this critically low threshold, there is insufficient O<sub>2</sub> to meet the requirements of the brain and, without much warning, the diver blacks out. Due to the rapid changes in pressure from 10m to the surface, this sudden loss of consciousness most commonly strikes around 5m from the surface. Hence the name, shallow water blackout. If not rescued quickly an unconscious diver will drown.

Free-divers often put themselves through intensive training, practicing long breath holds and training their body to fight the urge to breath. They may also learn to 'cheat' the body by mimicking breathing motions with the chest muscles and temporarily suppress the reflex urge to breathe. This compounds the problem and is why experienced freedivers have to be particularly careful.

Putting all this into perspective, remember that many free-dives are conducted safely and without incident. Here are some practical steps that can be taken to minimise the risk.

### **Steps to minimise risk of shallow water blackout:**

1. Do not hyperventilate to excess - no more than 2 or 3 slow deep breaths.
2. Recognise that strenuous exercise will reduce your safe bottom time considerably.
3. Don't use tricks to cheat the urge to breathe, terminate the dive as soon as you feel uncomfortable.
4. Don't stay down until you are desperate to breath, leave the bottom while you still feel comfortable and allow plenty of time to get to the surface (Some recommendations say keep dives to shorter than 90 seconds. This should not be considered a 'goal' to aim for but rather time to leave the bottom even if you are still comfortable at this time). If you must make a longer deep dive be sure to have a 'buddy' standing by using the 'one up one down' system, or a safety scuba diver.
5. Rest for several minutes between dives as it takes time to breathe out the excess carbon dioxide.
6. Get yourself a well fitting wetsuit of appropriate thickness for the water temperature you dive in (as a guide, most freedivers in the temperate waters of the Auckland area wear a 5mm suit all year round). Ideally it should be a suit designed with freediving in mind.
7. Adjust your weights so that you are neutrally buoyant at about 5 m (15 ft) below the surface. (Eg: A diver wearing a 7mm wetsuit neutrally weighted at the surface will be 6kg overweight when he/she begins their long ascent from 20m).
8. Streamline yourself as much as possible, with long fins and a low profile mask, to reduce energy expenditure.
9. Get professional training to equip you with both the knowledge and the practical skills.
10. Dive with an experienced mentor.