Diving on a CCR Rebreather
Text: Brett Human; Photos: Errol Harding

Rebreathers are the future of diving. The past decade has seen a rapid growth in the development and availability of rebreathers aimed at the recreational market, with several models now going into mass production. An article in the November 2005 issue of DiveLog, about the annual DEMA show in the US, is testament to the number of models in the market place and their growing acceptance, and growing demand, in the recreational dive community. There are already dive charters that cater specifically to rebreather divers in the Bahamas and I believe also in the Red Sea (?).

If you don't know what all the fuss is about with rebreathers, it's all about breathing gas economy. Imagine doing a week of diving at Coobowie or Mt. Gambier without having to refill a tank! The diving equipment that we're all familiar with is termed **open circuit** (**OC**). With each exhalation, we expel the gas we have inhaled into the external environment. The problem with this is that our exhaled gas still contains somewhere in the region of 17% oxygen, which is very wasteful. The beauty of a rebreather is that it **removes the carbon dioxide** waste gas from our exhaled breath, which allows the exhaled gas to be recycled and rebreathed. Not only does this give longer bottom times (because your dive time is limited by decompression obligations rather than gas supply), but it also means that when diving on other gas mixes such as nitrox or helium based mixes, the cost of filling is dramatically reduced because you are filling less often than with OC.

There are several types of rebreathers, including **oxygen** rebreathers, **semi-closed** rebreathers (**SCR**) and **closed circuit** rebreathers (**CCR**). They all operate on the same basic principle but differ in the way they deliver the breathing gas. For an excellent description of how rebreathers work and the differences between the different types of rebreathers, see the article on the IANTD website at http://www.iantd.com/rebreather/rb.html, it explains things for the novice, but is also a good article for the not-so-novice as it explains things very well.

Fresh from doing my technical and trimix diving courses, I arrived back in Adelaide to learn that a family friend, Errol Harding, a well known diving personality in Adelaide, was building his own CCR. Errol has been developing his **Abyss Rebreather** for the last six years (http://rebreathers.com.au/History/abyss.html and http://www.therebreathersite.nl/errol_john_harding.htm). In most CCR's the addition of oxygen into the breathing mix is controlled by a solenoid linked to an oxygen sensor, however this means that electronics are unavoidable in the unit, and we all know that electronics and water do not mix! To get around this problem, Errol designed the Abyss Rebreather to **passively inject oxygen** into the breathing mix. We metabolise oxygen at a fairly constant rate, so by adjusting the flow rate of the oxygen into the breathing mix (via a bleed valve in the Abyss) to match the rate at which you metabolise oxygen, you can control the **FO_2** and **PO_2** of your breathing mix. Plus, you've also eliminated the need for electronics in the unit, besides the obligatory oxygen analysers.

Because of my technical diving background, Errol invited me to dive one of his Abyss units. Without hesitation I accepted, and we were off for a dive at Pt. Noarlunga. The Abyss is **no heavier than normal OC scuba equipment** (total weight is 17kg as of Nov., 2005) and feels no different to wearing OC gear, both on land and in the water. The only noticeable difference is the fact that you have two hoses connected to your second stage regulator (which is larger than an OC second stage), one for inhaled gas and one for exhaled gas. In the water, these hoses have a tendency to float because of their large bore compared to OC high pressure lines, and as a result tend to pull the mouthpiece away from your mouth when you are diving. I did find this a bit annoying, but this is a problem common to all rebreathers and there are weights available that you can put on your inhalation and exhalation hoses to counter this, or you would probably get used to it with time.

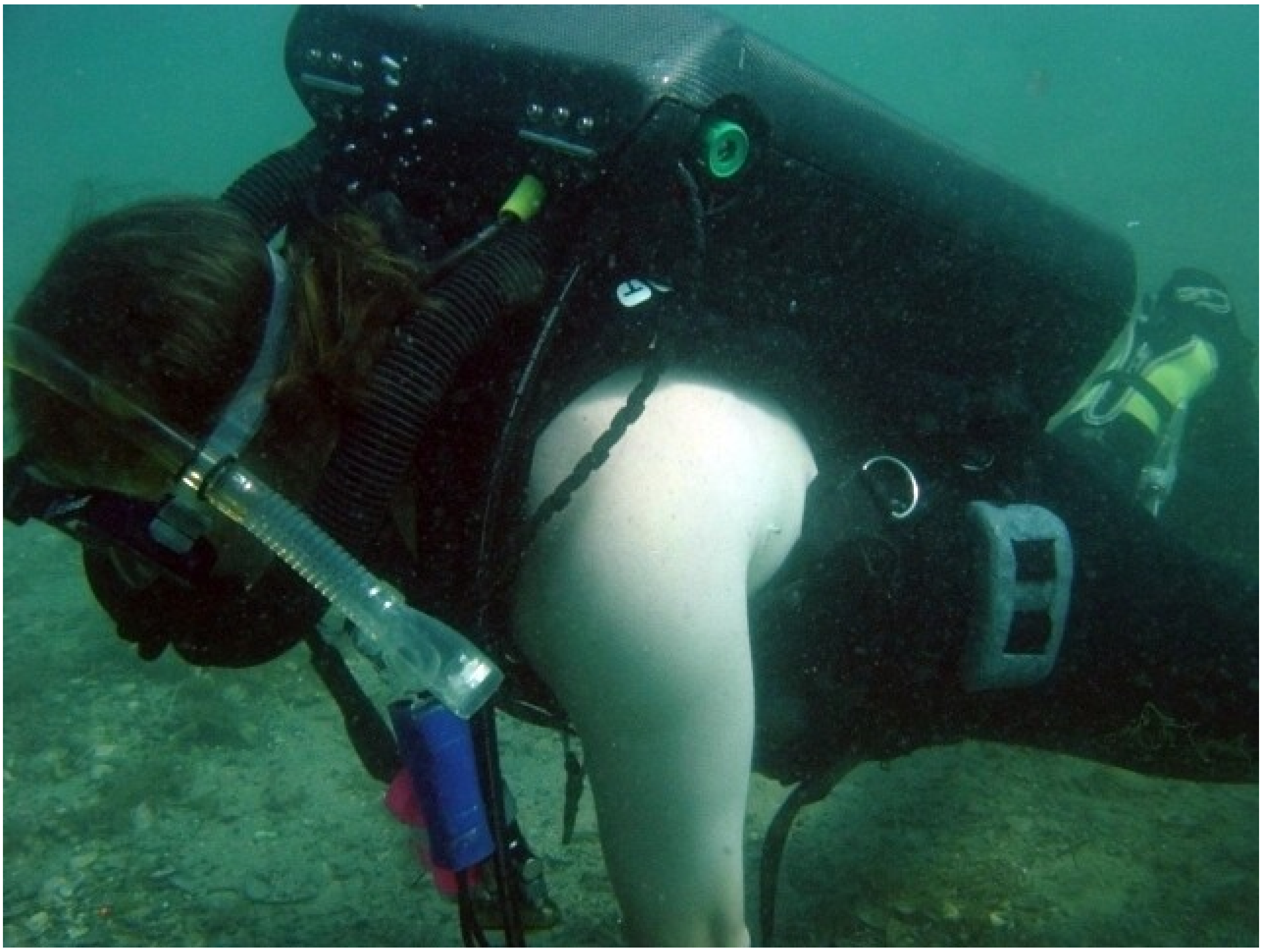
Performance in the water – although the weight and feel of a rebreather in the water is similar to OC equipment, there are some very obvious differences in the characteristics of a rebreather in the water compared to OC. With OC, when the inhalation pressure cracks the demand valve on the second stage, you get a rush of breathing gas. You do not get this sensation with a rebreather because you are breathing passively from the counterlung. There is no sensation of pressure, which can be a little unnerving to get used to because you're not getting that positive reassertion of abundance of breathing gas (although the reverse is actually true!). Another subtlety with breathing is that with OC equipment, you breathe the gas almost directly out of the gas cylinder. When filling your cylinder, the compressor has filters that remove the water vapour from the gas, so you breathe dry gas. In addition to this, the rapid expansion of the gas from the dive cylinder through your regulators and eventually into your mouth causes the gas to cool. With a rebreather, you are breathing your recycled breath, so the gas you breathe is warm and humid. Additional gas is added into the counterlung, which is warmed and humidified by the gas already in the counterlung, by the time you eventually breathe it.

This is a bonus when diving in cold water because you reduce your **thermal stress** (particularly important when diving helium based gases), and is a bonus when diving in warm water because there is **less dehydration**. With the dry gas you breathe in OC, **water vapour loss** from the lungs is quite considerable. How considerable could water vapour loss be from the lungs, I hear you say? Decompression algorithms have factors that account for the water vapour in our lungs before and after we take a breath, which is measured as **water vapour pressure**. The loss of water vapour from our lungs actually is quite significant in determining how much nitrogen we are able to diffuse into, and out of, our blood via the lungs. If you think about it, the surface of your lungs are 'wet' when you breathe in, allowing nitrogen (and other gases) to diffuse easily via the lungs **into the blood**, however, by the time we start breathing out, the water vapour from the surface of our lungs has evaporated from the surface of our lungs into the dry gas in our lungs, causing the surface of our lungs to be relatively 'dry', reducing the efficiency of gasses to diffuse **out of the blood** and into the lungs to be expelled. So, gas transfer efficiency is greater when breathing warm, humid gas, particularly with diffusion of gas out of the blood, compared to breathing cold, dry gas. As far as I am aware, decompression algorithms in dive computers for rebreathers use the same water vapour pressures as they do for OC diving, so there is an intrinsic physiological bonus in terms of decompression when breathing a rebreather compared to OC.

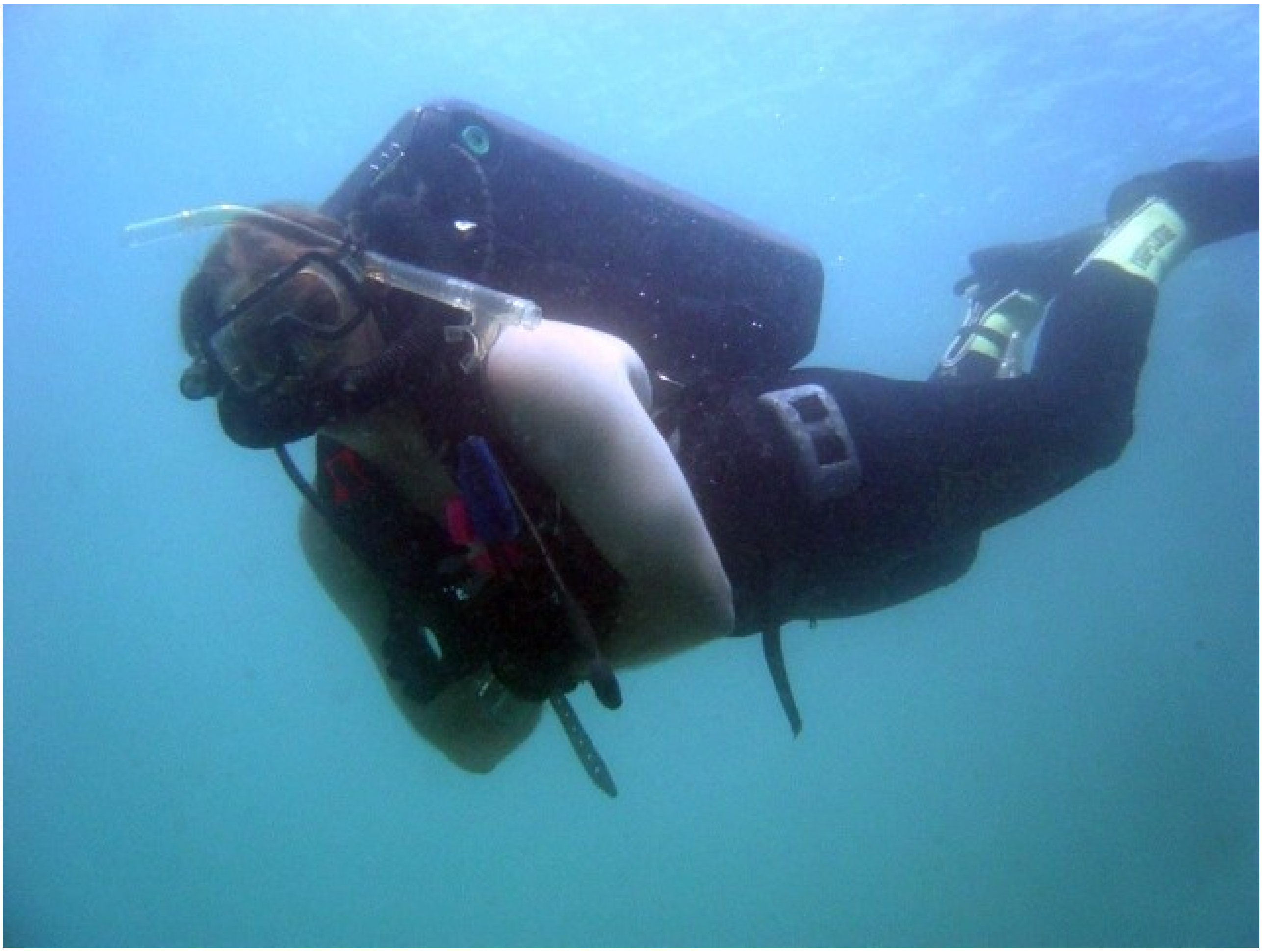
One final big advantage of the rebreather is that it is near **silent**. You occasionally hear gas being added to the gas mix (when you manually add gas, I never heard the oxygen constant bleed valve), sometimes you hear the gas move around in the counterlung like you hear the gas move around in your BCD, and there is some venting of gas from the counterlung when you ascend (again, similar to the sound of gently dumping your BCD), but the only noise you hear when you breathe is of you breathing! No hissing when you inhale, no thunder of bubbles as you exhale. It's actually surprising to learn just how noisy OC is! A rebreather is an **underwater photographers delight**!

Although my dive was only half an hour, exploiting only a fraction of the gas supply time available to me, I had set my PO_2 to about 1.0 (equivalent to breathing 100% oxygen at the surface), which meant that during the entire dive, I had not absorbed any additional nitrogen. In fact **I had actually off-gassed nitrogen during my dive**, so it was as though I had not dived in terms of decompression obligation. At the end of that half hour, I had become quite comfortable with using the unit.

As the popularity of rebreathers increases, the prices will lower, making it more affordable for everyday recreational divers. By removing the need for complex electronics and opting for simplicity, the **Abyss Rebreather** is also one of the cheapest, lightest and most compact CCR's available on the market today. Rebreathers really are the future of diving, and the future is now!



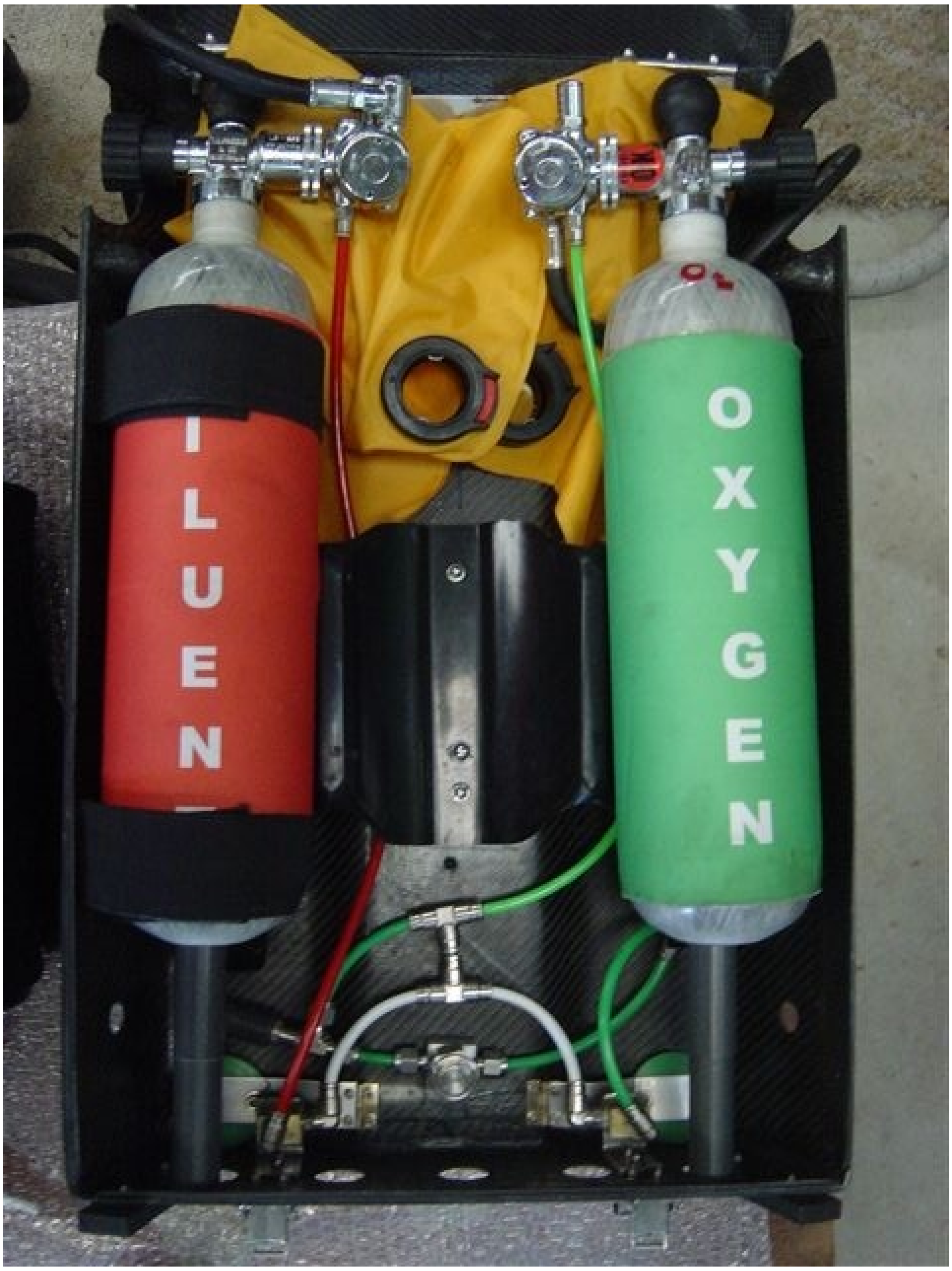
The Abyss Rebreather (March, 2004 version shown), is one of the most compact, simplistic and affordable CCR rebreathers available on the market. It has two 1.5L cylinders (capable of carrying two 3L cylinders), one for oxygen, and one for diluent, which on this dive was air. This combination gives you approximately 20 hours of gas supply! The blue thing over my left shoulder is a neoprene cover for the triple oxygen sensor display to monitor your PO_2.



A few minutes is all I needed to get a handle on the buoyancy characteristics and the general ‘feel’ of the rebreather, and then it was smooth sailing. The CO_2 scrubber of the Abyss gives you about 3-4 hours before you need to change the absorbent material.

No bubbles = up close and personal with the fishies! The pink regulator (also the BCD inflator/deflator) is connected directly to the diluent cylinder, so that in case of a flooded breathing loop, you can bail out to open circuit.

The latest revision of the Abyss rebreather (Nov. 2005). Here we see the front of the unit with revised triple oxygen sensor display lying between the diluent SPG and the OC bailout/ BCD inflator (with red buttons and mouthpiece) on the left hand side of the unit. The SPG for the oxygen cylinder is on the right hand side of the unit. Unlike watching the needle on the SPG of OC equipment, the needles on these SPG's move very slowly indeed!



Here is the inside of the unit, showing the arrangement within the carbon fibre shell. The yellow bags are the counterlungs, and these latest cylinders (made of composite materials) are super high-pressure cylinders with a working pressure of 800bar! The various other lines lead to the counterlung, OC bailout, and the manual gas addition valves (the buttons for manual addition are recessed into the bottom of the unit). Not in this photo is the CO_2 scrubber that sits in the bracket between the cylinders. Also not shown here is the breathing loop, the hoses of which simply click into the black ports you can see on the counterlungs. Note the distinct absence of electronics. The oxygen sensors are mounted in the CO_2 scrubber canister.