text william goodman and simon liddiard photos ari martinez

# LOOK BEFORE YOU LEAP

## Research and risk assessment

**IN THE LAST ISSUE** of *Asian Diver*, we introduced the Blue Marlin Technical Dive Team. On the deep walls of Gili Trawangan, Indonesia, the team plans to set a new Closed Circuit Rebreather (CCR) depth record of 300 metres.

In order to plan the dive, our initial training focuses on understanding the inherent risks of deep CCR diving. The dive plan that is formulated takes into account all the risks to the diver and puts together a procedure for a positive outcome for every eventuality. The first step, as with any dive plan, is to conduct a thorough risk assessment.

Will Goodman and Simon Liddiard's extensive experience in deep diving, along with current information readily available online, has helped to make Will's dive possible.

Online access to decades of research in decompression algorithms, scientific papers and physiological knowledge is invaluable alongside modern training principles, accident reports and technological advances in equipment.

Most problems with CCRs can be dealt with by switching to an open circuit gas source. Broken or lost equipment should be replaced by a fully functioning backup set. Research has shown that a faulty, redundant kit is a major contributing factor to accidents. Therefore, our training dives focus on testing this redundant equipment by conducting multiple bailout scenarios.

For example, a spare mask is considered to be one of the most important pieces of backup kit. We are amazed when we see technical divers who don't carry one.

Imagine conducting an ascent from 300 metres followed by eight hours of decompression with no mask. Equipment required to execute the dive must be backed up.

Will Goodman, chillin' with his JJ-CCR during a deco stop

On ascent helium comes out of solution much quicker and there is evidence that the decompression time for longer, deeper profiles is actually quicker than shallower ones.


Our initial Risk Assessment was fairly straightforward and is covered in the IART and TDI course material that we teach our students daily. For example, what to do if your rebreather floods with water, making breathing impossible, a hose bursts, electronic or computer failure, equipment and gas loss.

We had an appropriate course of action for all eventualities until we started to look at depths below 200 metres. Here are some of our findings, concerns and management strategies:

- **Loss of vision:** 200 metres is the absolute limit for natural light to penetrate. We are spoilt by the warm, clear, nutrient rich waters of Indonesia, which negate the use of a light, even on a 150 metres deep trimix dive. We are currently sourcing compact torches with a suitable depth rating and the duration to last the deep portion of the dive.

  The effects of diving into the darkness may also have an adverse psychological effect. This will be managed by conducting progressive training dives so Will can adapt to the environment.

- **Computer failure:** Most dive computers, dive timers and watches have 200 metres depth rating. Time and decompression obligations are absolutely critical to ensuring diver safety. When diving using a CCR, the $PO_2$ is also displayed on the handset. The JJ CCR is controlled by a Shearwater handset, which has never been tested by a diver beyond 240 metres.

  The possibility of it failing at depth needs to be addressed. The diver would lose depth, time, decompression information and the $PO_2$ display.

  The triple redundancy design of the JJ CCR allows for oxygen injection to continue in the event of computer failure. The $PO_2$ of the breathing mix can also be monitored on the HUD (heads up display) that is independently calibrated. Finally, if the Solenoid fails, the diver can manually inject oxygen to maintain optimum $PO_2$.

  This just leaves the decompression information. We will use Liquivison X1 and XEO computers supplied by RMS Technical in Singapore. They are calibrated at 500m and can externally monitor the $PO_2$ in the breathing loop.

  The current CCR depth record of 283 metres was conducted using a Liquivision X1. Out of seven computers tested it was the only one that worked throughout the dive.

- **Hypothermia** is a serious risk and cold is a major factor in decompression sickness due to reduced blood flow. Excessive depths, thermoclines, and high concentrations of helium in the mix add up to a lot of underwater time required to do the dive.

  Helium is essential to reduce $PO_2$ and nitrogen narcosis. Unfortunately, helium increases the decompression schedule on relatively shorter dives because it dissolves into the body's tissues approximately 2.5 times quicker than nitrogen. Advanced Trimix divers will be well aware of this.

  On ascent helium comes out of solution much quicker and there is evidence that the decompression time for longer, deeper profiles is actually quicker than shallower ones. Regardless of this, the dive profile will still be eight hours.

  Helium conducts heat away from the body very quickly due to low gas density and further exaggerates the cold problem. In 2010, O'Three from the UK sponsored Will's successful "Longest Open Saltwater Scuba Dive" by providing a semi dry wetsuit that kept him warm for 48 hours. We have chosen this suit again. We decided not to use dry suits due to previous dive experience. We were actually colder using them. The 32-degree air temperature makes you perspire while kitting up. This perspiration freezes you at depth.

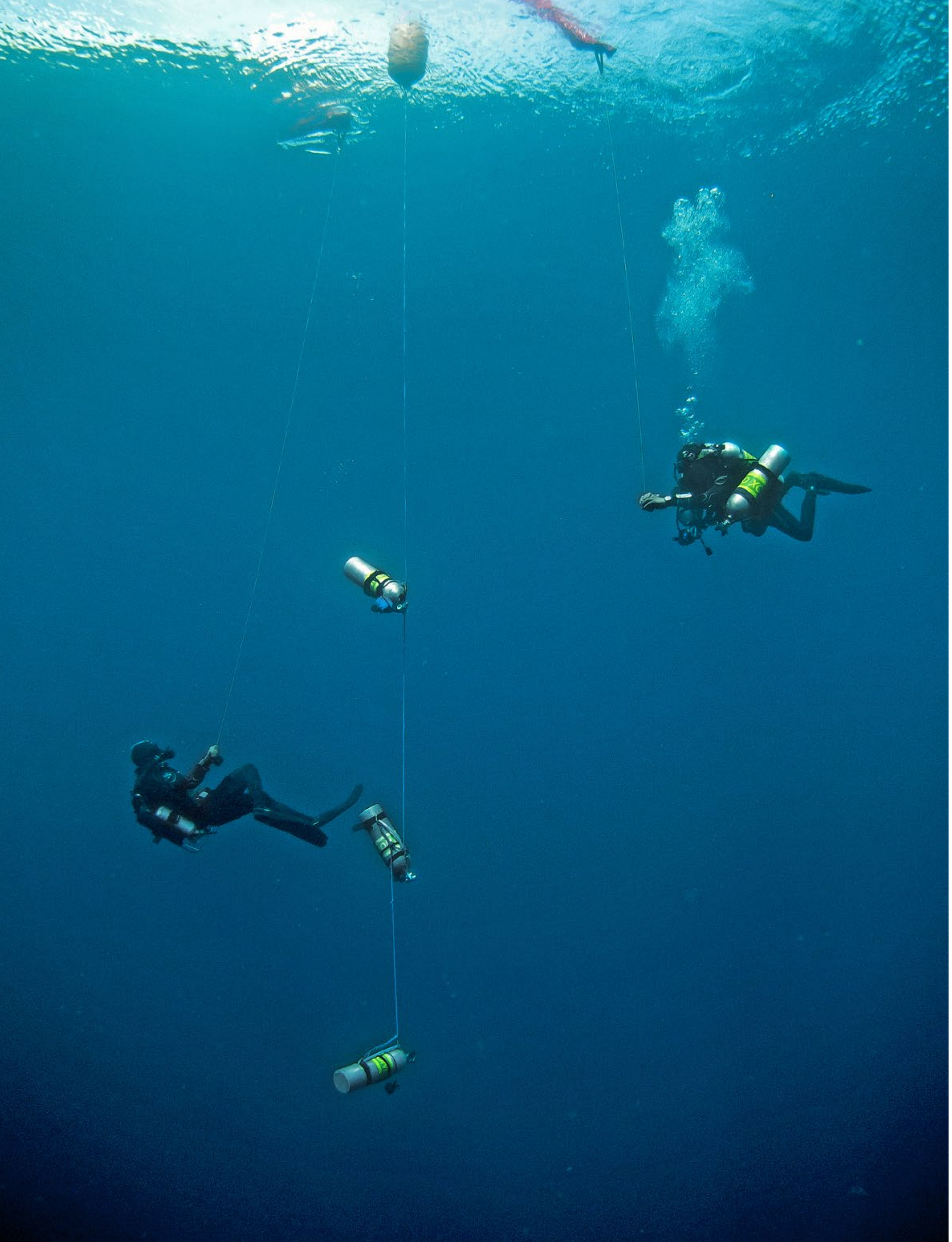
- **Decompression Sickness** The Bends is a risk with any dive. Cold, dehydration, rapid ascent and poor physiology are all contributing factors. Most technical divers prefer a CCR as the warm moist air reduces the risk of cold and dehydration.

  In addition, the constant $PO_2$ or "setpoint" means the diver is consistently delivered the optimum breathing mix regardless of depth. A CCR is therefore more efficient at reducing decompression times. It also eliminates gas switches, potential for regulator failure and task loading on ascent.

- **Central Nervous System** Oxygen toxicity (CNS) is the result of breathing a high $PO_2$ for too long. Symptoms, if any, will ultimately end in a convulsion underwater and drowning, unless a full-face mask is used or the diver's mouthpiece remains in place. Each diver's own susceptibility varies and factors such as $CO_2$ build up can make the situation worse. In order to minimise nitrogen loading and to accelerate the decompression schedule, a CCR diver normally dives with a setpoint of 1.2 or 1.3.


↑ Gear in check: Pool test before a deep plunge

↗ Will (right) with a companion from a check out dive



However there is a risk of the $PO_2$ spiking to a dangerous level at depth. We plan to deal with this by using a setpoint of 1.0 for the dive and doing a 5-minute "air break" every 20 minutes once we reach our CNS limits. Switching to a lower $PO_2$ of less than .5 during the decompression phase of the dive will reduce the cumulative effects of CNS.

- **Pulmonary Oxygen Toxicity** is measured in OTUs (Oxygen Toxicity Units) and is the result of breathing a $PO_2$ higher than .5 for extended periods of time. Symptoms include difficulty in breathing, a dry cough, painful inhalations and chest pain due to the irritation of oxygen in the lungs.

  Treatment is to breathe humidified or normal air and the symptoms will go away given time. It is possible that this will happen as the maximum 850 OTUs allowed for a single dive may be exceeded. Healthy lungs and a CCR with warm moist breathing gas will help.

- **HPNS** or High-Pressure Nervous Syndrome is a phenomenon that affects the brain cortex, spinal cord and primary nervous system. Symptoms include dizziness, nausea, vomiting, micro sleep, tremors and changes in brainwave activity, all of which will affect a diver's ability to perform tasks. HPNS is primarily caused by the compression rate of helium in the body when diving below 180 metres.

  In previous open circuit deep dives, HPNS has been avoided by offsetting the amount of helium by buffering the mix with nitrogen. This can be dangerous as the diver is operating on a high Equivalent Narcotic Depth (END) of up to 70 metres. Diving below 200 metres with a narcosis level this high may seriously affect Will's ability to react quickly and appropriately to a problem.

  Another disadvantage of a high END is specific to CCR. The gas density is increased and this will affect the Work Of Breathing (WOB), which can lead to a deadly $CO_2$ hit. These risks mean diving on a high END is not an option.

  We aim to reduce the effects of HPNS by slowing down the descent and in turn the rate at which the gas is absorbed. This will give more deco, diver cooling and CNS accumulation. The training dives will incorporate a moderate trimix with a 30 metres END and one dive using heliox (helium and oxygen, no nitrogen). Both methods will be tested to see which works best for us with our primary focus on WOB whilst minimising and managing the effects of HPNS.

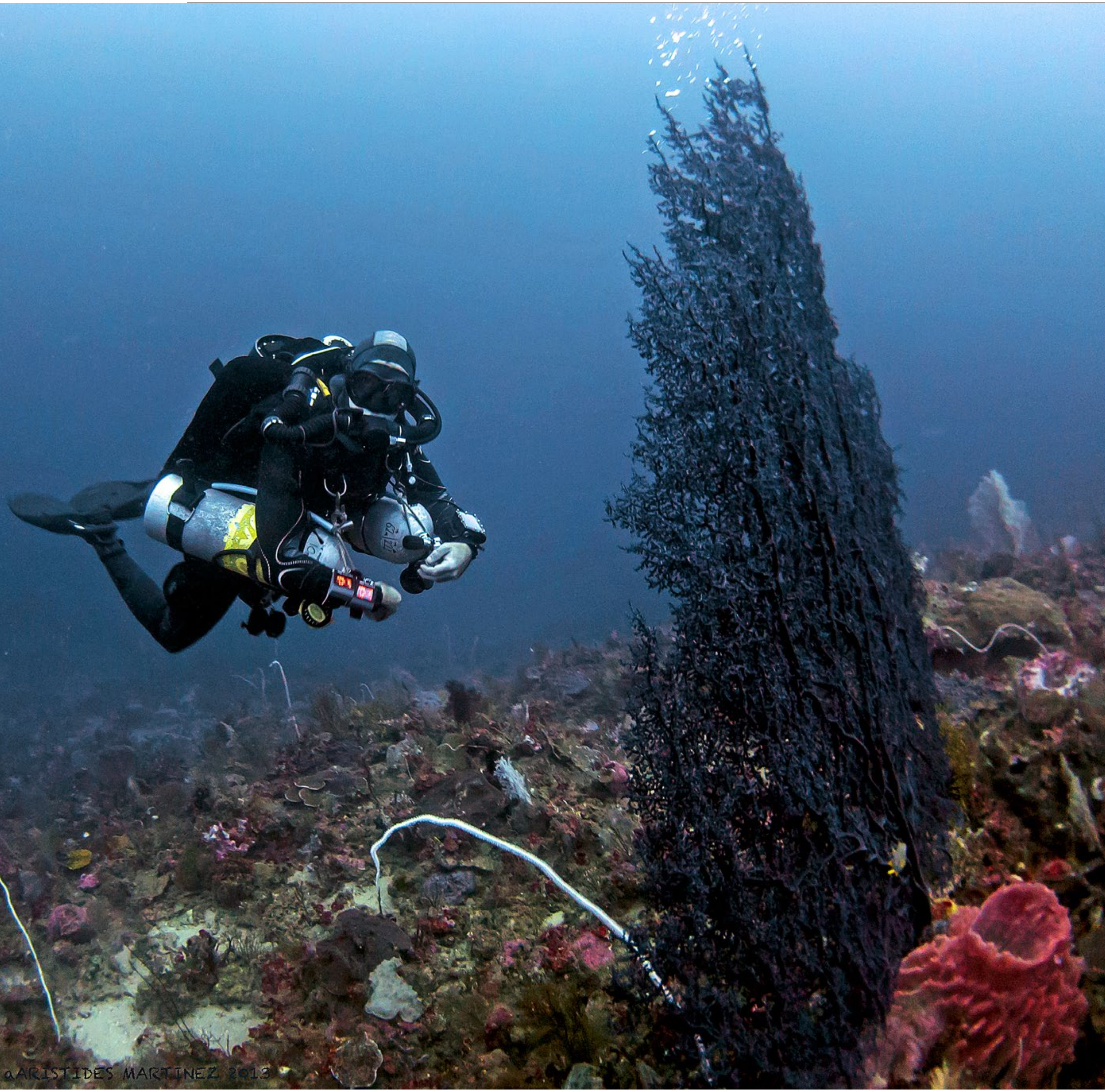
- **$CO_2$**, we tell our students, is the diver's enemy and my worst fear. It is an antagonist for the bends, CNS and narcosis. A rebreather relies on a chemical scrubber to remove the $CO_2$ produced by the diver and normally lasts three to four hours. Should this absorbent fail due to overuse, flooding, or incorrect filling, a $CO_2$ hit will quickly follow.

  Symptoms would include: difficulty in breathing, loss of motor skills, muscle cramps, inability to think clearly, sheer panic and eventually unconsciousness and death. It is almost impossible to recover from. There have been numerous deaths due to carbon dioxide build up and most famously the unfortunate Dave Shaw incident, documented in Phillip Finch's *Diving into Darkness*.

  Below 200 metres, there is the risk of independent respiratory failure due to increased gas densities. This means the body, even at moderate work rate, is unable to expel $CO_2$ produced and a hit becomes inevitable. The dilemma is that Will needs to be able to breathe easily at depth and mix selection will play an important part in managing this risk.

← Hang time at 55 metres

↓ Will's wonder gear: A life support system at crazy depths




Any nitrogen will buffer HPNS, but thicken up the gas, increasing WOB. Heliox will thin out the gas and increase HPNS risk, but due to gas density, it may flow too quickly through the scrubber, reducing the efficiency of the $CO_2$ absorbent. We plan to reduce the risk of a $CO_2$ hit by changing to a fresh CCR with unused absorbent during deco and maintain a calm, relaxed breathing pattern throughout the dive whilst minimising workload.

## A TRAINING UPDATE

The first few training dives started in a pool, trying out various equipment configurations whilst fully kitted and handling multiple stage tanks. A series of 50 shallow dives, to a maximum depth of 40 metres, using the new computers and semi-dry wetsuit were completed to ensure equipment familiarity, buoyancy and comfort were not going to be an issue on deeper dives.

From there Will progressed to some intermediate depth Trimix dives to a maximum depth of 60 metres. Handling multiple stages, comparing settings on the computers and swimming efficiency were the main focus.

Finally, three more deep training dives were conducted to a maximum depth of 110 metres. During the deepest dive a full open circuit bailout from depth was successfully completed without assistance from the support team. The idea was to practise the escape route back to the surface should the CCR fail. Will carried four 11-litre stages, two reels, two SMBs, three computers, cutting devices, slates and a spare mask. AD

In the next issue, we will follow Simon and Will's progress laying the descent line down the wall to 185 metres. We will outline the dive profile and gas used, highlight their observations, personal fitness-training regime and mental preparation, and take a closer look at the technical diver's mindset and physiology that is required to safely execute any technical dive.

Will testing every system and procedure during a consistent risk management round

**WILL GOODMAN** Will currently works on Gili Trawangan as Blue Marlin Dive's senior technical diving instructor. He is a TDI Advanced Trimix and Mixed Gas CCR instructor, a PADI Staff Instructor and Tec Trimix Instructor and a professional within the technical diving community. He is also proud to be one of only two IART (International Association of Rebreather Trainers) JJ-CCR Instructors in Indonesia.

**SIMON LIDDIARD** Simon is the Director of PT Blue Marlin Dive located in Gili Trawangan, Indonesia. The company also operates a CCR Dive Resort and Liveaboard in Komodo National Park. He is an IANTD Instructor Trainer at Trimix level- both open circuit and CCR, a member of the IANTD Board of Advisors, a TDI Trimix Instructor Trainer, a PADI course director and DSAT Trimix Instructor Trainer. Currently, he is the only IART JJ-CCR level III Trimix Instructor in Indonesia.