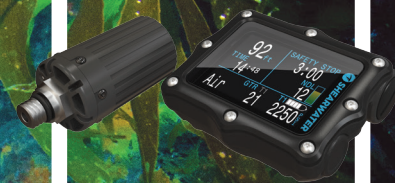


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HUMAN FACTORS IN DIVING

TEXT BY GARETH LOCK

Gareth Lock is an advanced trimix diver and CCR diver with many articles published on the role of human factors and human error in diving. He presents at diving conferences highlighting the need to be better understand decision-making, situational awareness, communication, and teamwork skills if we are to improve diving safety. He runs a company focusing on human performance, human factors, and human error. Since Jan 2016, he has delivered globally-unique classes focused on the subject of human factors in diving in both online and classroom-based contexts.

Applying the acceptance of fallibility to recreational and technical diving

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ive years ago I was doing an underwater photoshoot at an inland dive site that used to be a working quarry. I was working with some divers who were submerging a helicopter to act as an attraction for the diving public. For thermal protection I was wearing a drysuit that used a small suit-inflation bottle rather than the twinset on my back to feed the drysuit. We had already done quite a few ascents and descents before this final dive to assess where the helicopter was lying on the bottom and make sure everything was OK. I was floating upright on the surface waiting for the diving supervisor to start his brief when I realized that the inflator hose was leaking gas into my wing, making it uncomfortable to be upright, so I disconnected it. The brief lasted approximately 15 minutes and the supervisor signalled that they were ready to descend. I prepared my camera and strobes to get pictures of the divers descending onto the helicopter. As I tipped forward to be horizontal during the descent, I vented gas from the dump valve on the wing. I started to descend, taking photos as I went. However, at about 33ft (10m) my suit started getting very tight and I realised that my suit inflation bottle was empty. I started to accelerate downwards and then realized my wing was still disconnected! The depth of the quarry at its deepest was 260ft (78m); fortunately, the section I was over was only 80ft (25m) and I hit the bottom in a massive cloud of silt! Despite being shrink-wrapped I managed to take the wing-inflate hose and inflate my suit. I then manually inflated the wing by breathing into it and achieved neutral buoyancy, carrying on to finish the rest of the photo session. When I got home I took the inflator apart and cleaned the small amounts of rust that had built up since I last serviced it, which had been approximately 18 months before.

So what were the lessons learned here? You might think that skills and equipment would be the key factors. To a certain extent, equipment did play a part, but only because I hadn't followed a regular regime of cleaning the inflator. One could say that complacency led to this incident, but this is a simplistic view of the situation. It's the same as applying 'pilot error' to a plane crash or 'diver error/human error' to a diving fatality. The decision making processes we go through are often far more complicated than we think.

The 'obvious'

Diving is an activity that is discretionary in nature and where risk is managed, predominately at a personal level. The difficulty is in knowing how much risk you are taking, or even are willing to take, if you don't know the likelihood of the risk materialising. I don't mean how likely is an adverse outcome, death, or injury; but just how fallible your brain is, what is likely to cause you a problem in a dynamic situation, how you are influenced by biases when it comes to decision making, or even the likelihood of an event occurring where you could get injured or killed. The list goes on.

As has been shown in other

domains like aviation or healthcare, to really understand the issues at hand we need to have some knowledge of human factors. As humans we are capable of doing amazing things in very short periods of time and under immense social pressures, and yet we are also capable of making amazingly simple mistakes that end up with people dead or seriously injured. In many cases, the starting point and the people are the same. After the event, a negative outcome is often judged to have been obvious; yet if it had been that obvious, those involved probably wouldn't have done it!

A counter argument for not applying those lessons learned

in other domains, like the use of checklists or undertaking effective briefs or debriefs, is because areas like aviation and healthcare are more complicated than sport diving – sport divers are just there to have fun. However, the pre-landing check for a 747 has four lines, one of which is to make sure the gear is put down! The World Health Organisation Safe Surgical Checklist includes the following items: identify the patient's name and ensure the site of the surgery is clearly marked, which you would think would be obvious. However, despite such things being obvious, aircraft still land with their landing gear up and the wrong site/wrong

IF NOTHING ADVERSE
HAPPENS, WE CALL IT
EFFICIENCY; IF IT ALL
GOES WRONG WE CALL
IT COMPLACENCY

Photo: Gareth Lock

patient surgery still occurs. While these occurrences still happen, their prevalence has been massively reduced through the adoption of human factors and ergonomic practices into these domains. Such concepts and standards have yet to be formally adopted in the sport diving community.

More recently, the term 'normalisation of deviance' has been making its way into the discussions on social media and forums as a reason for why diving accidents happen. (See 'Creature of Habit' DIVER, Issue 42, No. 4.) The term originated following an investigation into the *Challenger* Space Shuttle disaster, in which organizational

risks were being accepted without fully understanding how far operations were from 'safe' conditions. Unfortunately, the normalisation of deviance led to the loss of *Columbia* when the tiles designed to protect the vehicle from the very high temperatures were dislodged during launch. These tiles were lost on most missions and it was accepted as a risk without necessarily understanding the full implications or even why the tiles were dislodging.

Case studies

If we look at a couple of examples from diving, we can highlight just how relevant human factors are

Haloclines can reduce situational awareness

and examine how the situations came to develop. Some might consider the 'chain of events' or 'incident pit' as a way of explaining how an accident happened. While this has some merit, the simplicity belies the complexity of the real world. The interactions between different elements often hide the likely outcome, interactions which often occur in a non-linear or combinatorial manner. Consequently, we should be looking at 'What is to blame' rather than 'Who is to blame' if we are to improve diving safety. People (divers) are a product of the system in which they reside or operate. We should all recognise that humans are fallible, and



Photo: Gareth Lock

therefore it is the circumstances and subsequent behaviours created from the system that we need to examine, not the individuals. Getting rid of the person without changing the system will continue to lead to the same outcome, but just with different people!

Example 1

The final dive of a Closed Circuit Rebreather (CCR) Module 1 class ended up with one of the students with 72% O₂ in his diluent bottle because of a sequence of events that started on the first day of the week-long class. This included the instructor acting as a poor role model by not analysing his own gas all week, despite the course standards saying he should. The students subsequently copied this behaviour, despite being Open Circuit (OC) Trimix qualified and Open Water (OW) instructors themselves. At the end of the first dive of the last day of the course, the remaining gas pressure in the student's diluent bottle wasn't checked and it was only noted during the final checks for the

second dive. By this point everyone was waiting to enter the water, so there was a rush to get the bottle filled. The student did not appreciate how much an O₂ fill cost in comparison to an air diluent fill, so he didn't pick up on the difference when he paid for his fill. The student made the assumption that the gas station had filled the diluent bottle with air and not another gas, like O₂. Finally, the student did not carry out a flush of the loop with diluent to ensure the O₂ cells responded correctly. Time pressures, role modelling, and assumptions all led to the diver entering the water with 72% O₂ in his diluent bottle. He did not realize it until he reached 60ft (18m) and couldn't get the pO₂ in the loop to come down to 1.3, despite conducting a diluent flush. He bailed out and made a safe ascent. At that point, it became clear what had happened. Many people would look on and say 'complacency'. But complacency can be described as a mismatch between the mental models created for a perfect world and the reality being experienced at that time. If nothing adverse

“Getting rid of the person without changing the system will lead to the same outcome, but with different people”

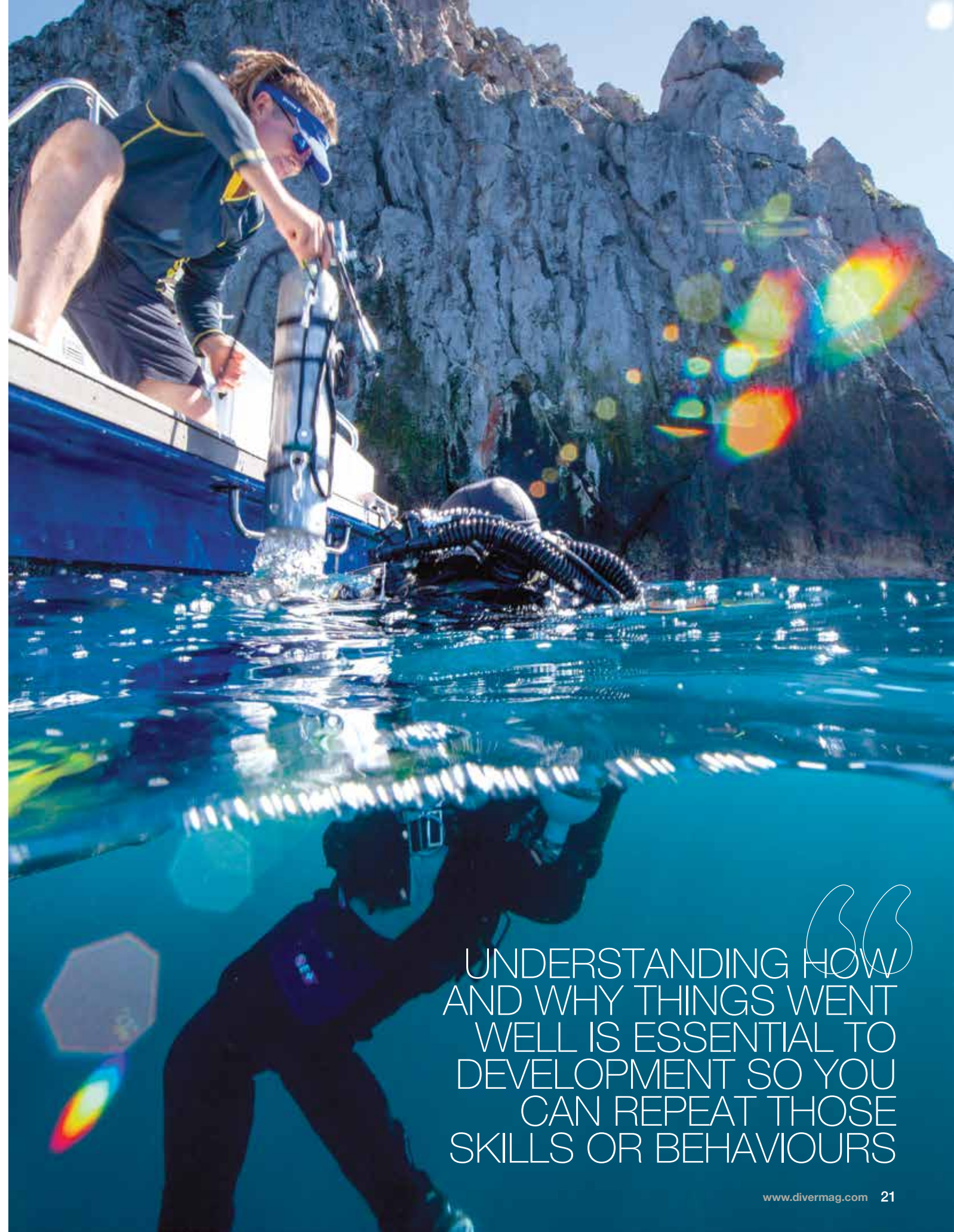
Rescue skills are essential to prevent situations from deteriorating further

happens, we call it efficiency; if it all goes wrong we call it complacency! We are also subject to 'outcome bias', where we judge things in a more critical manner if the outcome is negative.

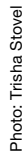
Example 2

A recently qualified Advanced Open Water diver felt significant peer pressure to help an instructor with four OW divers on a dive to 90ft (27m) and it nearly cost her life. From the outset she did not feel that the divers should have been on the dive but felt an obligation to the instructor, as the instructor had worked hard at getting them to complete their classes. Unfortunately, the subject diver's buddy was not very good at buoyancy control and at one point knocked the subject diver into some rocks which, unbeknownst

Photo: Trisha Stovel



“UNDERSTANDING HOW AND WHY THINGS WENT WELL IS ESSENTIAL TO DEVELOPMENT SO YOU CAN REPEAT THOSE SKILLS OR BEHAVIOURS”

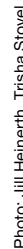


- The four divers probably shouldn't have been certified, especially if they couldn't be trusted to make

Peer pressure in this situation is normal and is known as an 'authority gradient'. This means that it is hard to question or challenge those more experienced or in senior positions, and is normally based on the assumption that those in the position of authority know what they are doing. But they are human, too! The subject diver in this case decided to no longer have

Safety related training for high risk environment can help us better understand our behaviour when diving, or task loading

Human factors are at the core of everything we do in sport diving: divers' physical interactions with their equipment; decision-making undertaken in stressful environments with limited situational awareness; instructors developing team skills so that their students can cope with complex situations; and organizations developing a just culture so that adverse events can be learned from and not just classified as 'human error'. The challenge is in realizing that these human factors apply to us all, irrespective of knowledge or experience. Even experts make mistakes.



Personal development of understanding our own limitations happens by being critical of our own activities, and by getting honest peer review. This does not mean platitudes. Back-slapping doesn't help anyone

So how relevant is human factors to diving? The knowledge, understanding and practice of human factors are incredibly relevant to any area where excellent human performance is needed, and that includes recreational and technical diving. Fundamentally, because we are human, we make errors, we make mistakes, we fail, and we drift. We can't stop those errors from occurring completely, but we can raise our awareness as to the issues we face, and hopefully catch them before an injury or death occurs. []



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