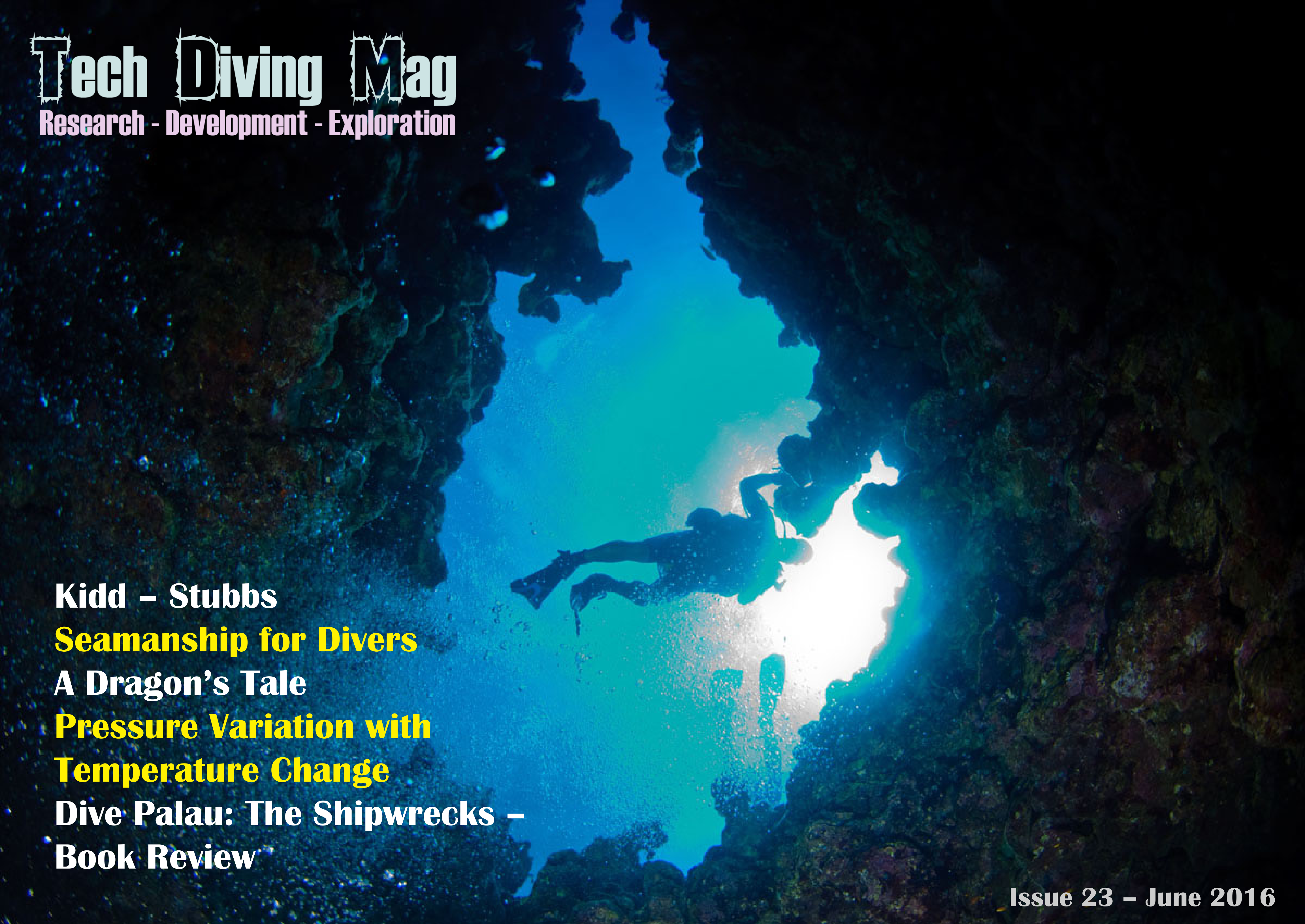

Tech Diving Mag

Research - Development - Exploration

Kidd – Stubbs

Seamanship for Divers

A Dragon's Tale

Pressure Variation with Temperature Change

Dive Palau: The Shipwrecks – Book Review

Issue 23 – June 2016

Contents

Front cover image © T. Timothy Smith.

Editorial

Welcome to the 23rd issue of Tech Diving Mag.

Those who reported broken links, Best Publishing Co has updated their web site and now all three forms (print book, eBook and package set) of *Deep Into Deco: The Diver's Decompression Textbook* could be reached from a single page. The print book is also available through Amazon.

The contributors for this issue have brought together some unique, first-hand experiences. Our generous contributors are world renowned industry professional Bret Gilliam, technical diving instructor Julien Fortin and wreck and cave explorer Andy Sargent. Take a look at their brief bio at www.techdivingmag.com/contributors.html.

Tech Diving Mag is based on article contribution, so you're always welcome to volunteer a piece and/or some photos. The guidelines could be found at www.techdivingmag.com/guidelines.html.

This is very much your magazine, so if you want to share some views, just drop a line to asser@techdivingmag.com. And please subscribe to the newsletter at www.techdivingmag.com/communicate.html to be notified when new issues are available for download.

Asser Salama
Editor, Tech Diving Mag

Kidd – Stubbs

By Asser Salama

In 1962 Derek Kidd and Roy Stubbs started a program to develop a real-time dive instrument to calculate the required decompression obligation according to the depth-time history. Initial versions of this instrument were pneumatic, mechanical, analog computers, frequently referred to as Kidd–Stubbs pneumatic analog dive computers (K-S PADC).

Cavities into which the gas could enter at a controlled rate and pneumatic resistors consisting of micropores were used to simulate the different tissues in the human body and to describe the gas flow in and out of them. At first, Kidd and Stubbs used four compartments connected in parallel, which means they do not affect each other, along with the U.S. Navy algorithm to generate the required decompression schedule according to the real-time readings. They made a series of modifications to halftimes and supersaturation ratios to accommodate a wide spectrum of single and repetitive dives. The underlying mathematical expressions described the operation of a piece of hardware aiming to generate safe decompression schedules rather than a physiological model for decompression.

Kidd and Stubbs believed the gas transfer between the lungs and the body tissues would be better described by an interconnected series of compartments. Their assumption is an extension of the slab-diffusion concept. They arranged the four compartments in series, and assumed they are all bearing risk of DCS.

In 1970 it was discovered that an inherent distrust in the safety of the model for deep dives led the hyperbaric chamber operators to stay deeper than the computed safe ascent depth (SAD) by as much as 3 meters (10 feet). When the operators were instructed to follow the model exactly, the result was a whopping 20 percent incidence of DCS, compared with only 3.6 percent when they applied their own adjustments. The affected range was 60-91.5 meters (200-300 feet). In 1971 Stubbs analyzed the results and applied some correction factors, publishing the model later the same year.[1] The Defence and Civil Institute of Environmental Medicine (DCIEM) of Canada adopted it as a safer alternative to the U.S. Navy tables.

During the 1970s many single and repetitive dives were conducted using the pneumatic computer incorporating the 1971 algorithm. A microprocessor version of the dive computer was developed in the late 1970s.

In 1979 a critical study was initiated to evaluate the performance on the dive computer. It was discovered that the algorithm is generally safe, yet it is overconservative in some regions and overaggressive in others. In 1983 a modified version called DCIEM 1983 was derived. The new derivative had risk of DCS associated with only the two outermost compartments of the series. The two innermost compartments are nonrisk-bearing yet they influence the risk of DCS indirectly.[2] In 1992 the DCIEM manual was published with new tables generated by the modified model. Although generally less conservative than the former 1971 version, this set of tables enjoyed wide acceptance by the diving community and is considered one of the safest and most conservative. The modified model is also incorporated in one of Citizen's line of watches.

References

1. Kidd D, Stubbs RA, Weaver RS. Comparative approaches to prophylactic decompression. In: Lambertsen CJ, ed. Proceedings of the 4th Symposium on Underwater Physiology. New York: Academic Press; 1971:167–177.

2. Nishi RY, Lauckner GR. Development of the DCIEM 1983 Decompression Model for Compressed Air Diving. Downsview, Ontario: Defence and Civil Institute of Environmental Medicine; 1984.

Excerpted from *Deep Into Deco: The Diver's Decompression Textbook*. The title is available at:

https://www.bestpub.com/books/scientific-diving/product/428-deep-into-deco-the-diver-s-decompression-textbook/category_pathway-42.html

http://www.amazon.com/Deep-Into-Deco-Decompression-Textbook/dp/1930536798

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"*Deep Into Deco* is a stimulating read which covers almost every facet of diving from breathing to technical decompression. It is well referenced and dives into (forgive the pun) great detail concerning the past and present of diving theories. I recommend this book for all divers from novice to technical expert because Asser Salama makes even the most difficult topics seem easy and understandable. No diving collection is complete without this super overview book. I will keep mine on the coffee table as a discussion piece."

—Commander Joseph Dituri,
US Navy Saturation Diving Officer (ret) and Vice President of IANTD

"This book is long overdue. And it's worth the wait. What Asser Salama has accomplished with this book is remarkable. He has taken that early history of experimental trial and error and produced a stunning reference text that brings the science into sharp focus."

—Bret Gilliam, founder of TDI

"Asser's book is the best general overview of decompression modeling I have seen. The information it contains is relevant to divers of all levels, from the occasional sport diver who wants to know more about how their dive computer works to the technical diver planning extended decompression dives. It certainly is a welcome addition to my dive library!"

—Jeffrey Bozanic, PhD, author of *Mastering Rebreathers*

ASSER SALAMA, a technical diver and instructor, is founder of *Tech Diving Mag* and developer of Ultimate Planner decompression-planning software. He has a bachelor's degree in engineering and a master's degree in business administration. A software developer with an interest in decompression modeling, Salama plans to implement computational algorithms based on credible research papers to prevent some pioneering work from fading into academic obscurity.

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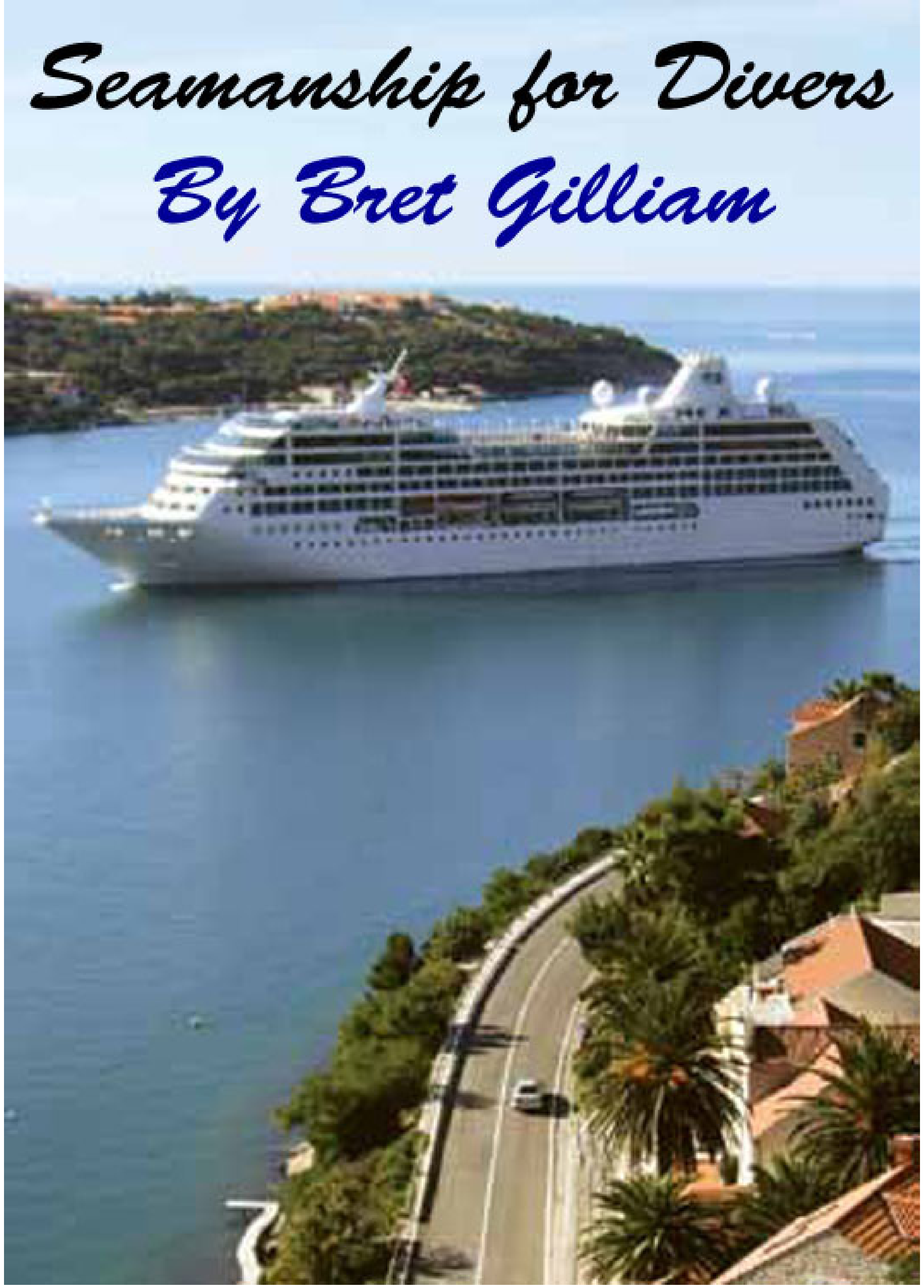


Looking for a job in dive and travel? Here's some good advice: embrace boating.

Learn the ropes on the water to get paid diving under it... in a nice warm sea somewhere.

If you're a diver, sooner or later you'll find yourself on a boat; maybe as a customer in search of the more exotic and remote sites, or maybe as an employee of a dive store or resort that operates boats as part of their business. If you're in the latter group or you're heading in that direction, read on, this is for you.

What should a diving instructor know about seamanship? Increasingly, your chances of getting hired at all may be predicated on your boating skills. Graduating from an instructor program is a worthy accomplishment but realistically such training is primarily geared to evaluating and refining teaching skills in order to conduct dive-training programs. This may substantially limit your options when it comes to testing the job market since little, if any, practical boat experience is offered. But if you want to make diving a career and give yourself the highest earning potential, then you're simply going to have to know your way around a boat without looking like one of the Three Stooges.

Consider the Competition

There are literally tens of thousands of instructors looking for jobs. Without the prerequisite of boating experience most will be overlooked by dive resort and liveaboard operators. If you contemplate working for a U.S.-based operation, it's important to know that their watercraft will come under the direct jurisdiction of the U.S. Coast Guard (USCG) with regard to crewing requirements, inspections and licensing. For foreign flag vessels that call on U.S. ports, the USCG's enforcement role may be more closely refined to address only Safety of Life at Sea (SOLAS) requirements. For foreign flag vessels operating in their home waters, regulations can be substantially different.

Editor's note: The references, rules and protocols described in this article are for U.S.-based passenger carrying vessels and can be very different in other parts of the world.

In the case of U.S. passenger-carrying vessels, all captains or operators must be properly licensed. In many cases, certain members of the crew may also be required to hold licenses as engineers or mates. Most employers will look for personnel holding multiple credentials, such as a licensed captain who's also a dive instructor. This is especially important in smaller operations where a limited staff must fulfill several functions, very often on short notice. Obviously, the candidate who can teach classes, fill tanks, run a computer, do store sales and handle the dive boat is going to get a longer look by a prospective employer. Licensing is best achieved combining specialized study with practical experience.

License to...

The U.S. Coast Guard requires two years of 'certified' sea time to qualify an applicant for an entry-level license. 'Certified' just means that someone has attested that the sea time actually took place. However, this time is not directly verified by the USCG.

Boats are expensive and easily damaged in the hands of an inexperienced operator. This sad fact of life brings up the next issue in hiring, where a business owner will express something like, "OK, this guy has got a license but does he really know how to run one of my boats?" This question is etched – forever – in your employer's mind, given the USCG does not require a practical boating test when you take your exam. It's a reality that leaves me bemused and baffled. You can't get a license to drive your grandma's old VW without first demonstrating proficiency that includes daring feats of parallel parking or starting from a stopped position on a steep incline with a stick shift or simply putting on turning signals at the appropriate time. But you can finesse your way into a license to be captain of a vessel of up to 200 tons and that's capable of carrying several hundred passengers, without ever demonstrating how to even tie off a line to a cleat.

Having hired at least one too many of these 'captains' in my time only to be reduced to amazement as they drove my boat into the dock or up on a sandbar, I now cast a rather jaundiced eye upon the licensing process in the USA. The U.S. Coast Guard argues that actual boat tests are too expensive. I know what they mean, having paid the repair bills following a few 'tests'. But licensing is a necessary evil providing a good theoretical basis of achievement, notwithstanding changes in the process that have given rise to confusion in recent years. In prior years, entry level or 'civilian' licenses in the U.S. were issued up to a maximum of 100 tons and were called Ocean Operator licenses. Holders of these were further restricted to coastal routes and maximum distances offshore. A motorboat operator's license restricted the holder to maximum six passengers. Above this limit and you were into another level: Merchant Marine officer licenses to Masters (captains), Mates, Engineers etc.

But revisions to the rules have muddied the American waters, so to speak. Many of the smaller licenses are now referred to as Near Coastal Master or Mate tickets. Qualifying as a ship's officer in one capacity or another involves considerably more training, knowledge and experience and, of course, a far more rigorous licensing process. With this in mind, if you want to work on a U.S. passenger-carrying vessel, I suggest you seek out one of the excellent training centers around the country that specialize in preparing you to pass the demanding written examination for your first license. In this phase, practical experience may not help you. You'll be tested on the rules of the road, USCG inspection requirements, fire fighting, first aid, general seamanship, navigation, pollution ordinances, etc. Take my advice: go to an exam prep center and they'll get you over that first hurdle. Your local Power Squadron will probably offer boating courses but these will not get you through a licensing exam.

Acquiring experience is another matter. It requires initiative and a bit of creativity. Volunteering to work on dive boats may well be the best entry-level ticket to free training. Most often it's a reasonable bargain for both parties. You'll get experience in a practical setting and the boat skipper gets some cheap labor, and only a low-grade ulcer. But jokes aside, many boat owners prefer training a crew member or deckhand from scratch, which can lead to a job offer once you learn your way around. Boat crews are notoriously transient and most captains are willing to work with a motivated newcomer who can pitch in and work his or her way up the ladder. Meanwhile you're getting real time towards a license.

Logging Experience

It'll be a while before you can expect to get any serious 'wheel time' (actually handling the vessel in tight quarters or making dock approaches), but most skippers will be happy to start you off standing watch, steering a compass course and basic navigation. At this time you should absorb as many general seamanship skills as possible. These include proper handling of lines, anchoring, safety drills, procedures for moving the boat on and off the dock or mooring, passenger relations and even such seemingly mundane tasks as painting and varnishing. Welcome practical experience at every opportunity. You will almost always learn something. Starting with smaller, outboard motor craft in the 20 to 25- foot (6-7.5m) range will give you a chance to see for yourself how a boat reacts to her helm. Practice leaving and approaching the slip or dock until these various maneuvers are second nature.

When you're comfortable with smaller boats, seek out opportunities on larger single engine vessels. A boat with a conventional shaft and propeller and a spade rudder will react far differently than an articulating outboard or stern drive system. If you can master a 35- to

40-foot (10.5-12m) single engine boat while backing up in a strong crosswind or current, you're close to earning your stripes. Twin-engine craft are more easily maneuvered since the boat can be pivoted on her engines but these boats are usually larger as well presenting more mass and inertia to deal with. Keep in mind that different operations will require different crew requirements. On dive boats operating 'day trips' there may be just a captain and deckhand. Typically, they'll both be involved in the dive operation. This provides an ideal learning experience since the deckhand/crew will handle many of the regular seamanship duties while the captain mans the wheel.

On larger vessels, more staff may be added. Some day boats in the 65-foot (20m) plus range will have a captain, mate and several deckhands or crew. Try to learn as much about each member's duties as possible so you can quickly and confidently fill in as needed. Larger vessels are also less forgiving of mistakes so remember the captain is counting on you to get your line over on time and properly made fast on maneuvers.

Liveaboard dive vessel staff perform many functions as a result of the limited crew berthing available. The candidate whose experience includes working in the galley or tending bar is an asset. Similarly, a person with mechanical skills will always be given priority. Nothing ever goes right for long when you're out on a boat. It's not necessary to be an engineer to make yourself valuable. Almost anyone can become proficient in basic maintenance and trouble-shooting with a little effort. One sure way to endear yourself to the skipper is to volunteer to learn the routine of engine check-outs: dipping the oil, checking belt tensions and coolant levels, battery fluids, and other routine engine room duties. On vessels less than 100 tons, the captain will handle much of the maintenance schedule himself so any knowledge you can pick up from a versatile operator is invaluable. Once you are comfortable and familiar with engine and generator check lists, ask for more technical instruction in changing water pump impellers, hoses, zincs and hands-on experience with electrical repairs, etc. A crew member who's handy with a wrench and knows his way around a toolbox will be a valuable addition to any operation.

Rank Yourself

In the last two decades we've seen a trend toward larger vessels, including those designed specifically for diving. As well, the more traditional cruise ships are adding diving staff to their activities department. Because these larger vessels are generally more formal with respect to uniforms and protocol, it's helpful to have at least a passing familiarity with rank and department insignia. A ship is usually staffed by deck officers, sometimes called the navigation officers, and by engineers and hotel staff. The Captain, or Master, is the senior deck officer and responsible for overall ship operation. His second in command is the First Officer or Staff Captain, who deals with everyday shipboard routine. The Chief Engineer oversees the mechanical sections while the Hotel Manager handles the primary passenger facilities.

A close examination of their shoulder-board or sleeve insignia will reveal their department. In the U.S. merchant marine, deck officers typically wear an 'anchor' while engineering staff wear a 'propeller', and so on. The ship captain and chief engineer will both display four gold stripes with other staff displaying fewer: three stripes to a first officer, two to a second and on down. In some foreign systems, the insignia is eliminated and an accent color is added near the gold bars to distinguish departments. Take the time to learn the system and you will be spared the embarrassment of addressing the hotel manager as 'captain'. My theory has always been that the grander and whiter the uniform... the less chance I had of getting dirty! Rarely is a cruise ship captain called on to turn a wrench in the engine room.

Crew Wanted

There is a definite need for good crew in this industry. But it's a very competitive market and experience is a definite plus. Combined with a license, diving instructor credentials can be parlayed into appreciable career earnings if you hook up with the right operation. The time spent 'learning the ropes' on a dive boat can be used to upgrade training and license grades. Many ex-dive boat skippers have gone on to pursue careers in yachting and shipping. Mates on luxury yachts can easily earn up to $75,000 with top captains commanding well into six figures.

Along the way, while acquiring the skills of the deck and of the engine operation, also be sure to get acquainted with the fundamentals of navigation. Again, most captains or mates are receptive to training crew that shows a willing interest. A working knowledge of practical piloting, dead reckoning, and chart work are a must for advancement. From that starting point a natural progression to electronic navigational aids will follow. The modern crewmember will be functional with radar, plotters and GPS. You may even find a patient skipper willing to introduce you to the fascinations of celestial sights with a sextant, pretty much a lost art in today's push-button marine industry.

You must also be able to speak the professional mariner's language. Bow, stern, draft, bulkhead, and many other terms are part of a seagoing lexicon that you must know like your mother tongue. Know the difference between 'weighing anchor' and 'making way'. Seamanship isn't just handling lines and learning not to spit into the wind. It's a combination of many skills that make you a working partner on a boat or ship. Attitude and a willingness to learn new responsibilities mark the entry-level deckhand bound for promotion.

I remember being taught to tie a bowline and how to plot a course for the first time. My marine career has given me a profound sense of satisfaction through the years and I welcome the opportunity to share my knowledge with others eager to learn. After some forty years at sea and commands from tugboats to cruise ships, I can't imagine a more exciting and fulfilling vocation. But then again, it's been said that I'll do anything to avoid getting a real job...

Captain Bret Gilliam Is a licensed USCG Merchant Marine Master and President of OCEAN TECH, a marine and diving consulting firm. His work includes design, construction and operation of diving vessels and luxury yachts. A 45-year veteran of the diving and shipping industry, he has commanded everything from naval research vessels to 550-foot (168m) cruise ships throughout the Atlantic, Caribbean and Pacific.

A Dragon's Tale: The IANTD (SA) Dragon's Breath (Drachenhauchloch) Expedition July 2015

By Andy Sargent

What would motivate anyone to engage in cave diving, arguably the world's most dangerous sport, is a difficult notion for most people to even begin to comprehend.

In my case the catalyst was a book called 'Raising the Dead' by author Phillip Finch, a true and extremely well written storey about cave diving in South Africa, and which once I had picked it up and started reading I was unable to put it down again, I found it inspirational and it introduced me to a man called Don Shirley and a place called Komati Springs. I read the book time and time again.

Don is one of the key individuals in the book, he is an ex-pat having lived in South Africa for almost 18 years, both a technical and cave diving instructor he lives and works at Komati Springs, about 300km east of Johannesburg. Komati previously known as Badgat, was an asbestos mine until 1972, when it closed. The mine flooded forming an outstanding inland dive site. In 2002 the site was rehabilitated back to nature and now it is the headquarters of the International Association of Nitrox and Technical Divers South Africa (IANTD SA).

I wanted to learn to cave dive, I wanted to learn with Don and I wanted to learn at Komati Springs. All I needed was a little push, surprisingly that came from my non-diving girlfriend Deb's.

In February 2014, Deb's and I travelled to Komati and I successfully completed my full Cave Course on open circuit scuba equipment, both Debs and I fell in love with Komati Springs and the wider Mpumalanga area. For a week I ate, drank and slept cave diving, I learnt many new skills and was tested in every way possible. Don is incredibly calm and collected, he is affable and inspires confidence, but he also has eyes like a hawk, even in the darkness of the cave, the smallest slip-up is immediately noted and committed to memory, you can't get away with a single thing, however small and insignificant.

When not involved in cave diving, swotting up on decompression theory, altitude diving, dive planning, or practicing practical skills, I spent all my time listening intently to Don's cave diving story's, many made the hairs on the back of my head stand to attention, but nonetheless they drew me enticingly into this underwater world of darkness.

He told me about Dragon's Breath cave in Namibia, and almost as an aside said I should go there with them, he didn't need to ask twice.

Back home I practiced my line laying on almost every dive, my local quarry at Capernwray looked like it had been invaded by demented spiders, and I took every opportunity to practice my cave skills in a local flooded slate mine, Hodge Close near Coniston in the Lake District. I arranged to go back to Komati twelve months later to dive the caves on my rebreather, and that's another story.

Then it happened, out of the blue, reality struck, just like a bolt of lightning, I had an official invite from Andre, Don's wife, to dive Dragon's Breath as part of an IANTD (SA) Expedition in July 2015.

I explored the internet to find out as much information as I could about Dragon's and quickly realised that this was far more ambitious than I had originally thought, I immediately joined the gym and although I had been a keen rock climber in my youth, I enlisted two caving friends, Howard and Sweeny, to knock me back into shape. Howard, for whom I have the utmost respect, did his own research into Dragon's and after several expletives and informing me that I needed 'my bumps feeling', he emphasised just how serious this expedition was and that I should not underestimate what I was letting myself in for. I had nine months to prepare.

Namibia, which derives its name from the Namib Desert, possibly the oldest desert in the world, is a large and sparsely populated country, gaining independence in 1990. It has a population 2.4 million, an area of 824,292 square kilometres (318,261 square miles), and its capital is Windhoek (pronounced vind-hook).

Namibia´s varied geology encompasses rock formations covering more than 2600 million years of the earth's history. Over one hundred and twenty caves have been discovered and mapped in Namibia to date, with most of them in the Otavi region, a dolomitic massif rising up to 2090 metres above sea level. Their depth ranges from just a few meters to 250 metres, but the main feature, is the presence in a relatively small area, of large subterranean lakes.

Dragon's Breath Cave, discovered in 1986 by the South African Speleology Association, is situated on Harasib Farm 46 kilometres (29 miles) northwest of Grootfontein, the dolomitic rocks here contain interbedded layers of limestone, marl and shale. Inside this cave lies the largest non-subglacial underground lake in the world (Guinness Book of World Records) with an area of almost 2 hectares (4.9 acres or 20000m^2) and having an extension of 180 m x 140 m, you could fit three football pitches inside the cave. Large parts of the cave remain unchartered and unexplored; its depth is unknown, though exploration prior to this expedition suggested that it was at least 105 m.

The lake is located around 60 metres below the caves entrance- a small fissure in the rocks-, the route from the cave entrance to the water required us to negotiate a steel ladder, then pass through the first restriction into an inclined chamber and over several boulders before reaching the choke. This was a serious restriction over a vertical drop requiring two abseils to reach the ledge below, a further three abseils took us via 'the closet' to 'the bridge' and finally down to 'the platform'. Entry and exit was physically demanding and required a high level of skill in both single rope and dry caving techniques.

The aim of the expedition was to explore the cave, and add to the data available. Each dive would expand existing knowledge and assist in the planning for subsequent dives and/or subsequent expeditions. 150m was agreed as the maximum depth for all dives on the expedition, this was not a target depth, rather a limitation set by the team during planning, having due regard to the bailout gas being carried for decompression emergencies. Some side mount diving was planned but this would be limited to 60m.

The fact that Dragon's Breath is at an altitude of 1596 metres above sea level has a significant impact on dive planning, decompression obligations are significantly longer than would be the case at sea level, for example a dive to 100 metres in Dragon's is the equivalent of a dive to 124 metres at sea level.

Because of the physical exertion involved in exiting the cave it was necessary to impose mandatory surface intervals before commencing the ascent. A diver who had completed less than 15 minutes decompression would require a minimum surface interval of 1 hour, over 15 minutes decompression then the minimum surface interval required was three hours before commencing the ascent, this was the norm.

Another major consideration was the geographically isolated location of Dragon's Breath, the nearest minor injury medical facility is 94km from the site, the nearest major hospital over 400 kilometres away at Windhoek. The nearest recompression chambers are either at Walvis

Bay in Namibia, some583 kilometres from the dive site and a drive of over 8 hours, or back in South Africa at either Johannesburg or Pretoria. During the initial planning of this trip it was decided that the initial treatment for a Decompression Illness would, providing the casualties symptoms allow, be by in water recompression (IWR), all divers had been formally trained through IANTD and two full IWR rigs would be available inside the cave. In the event of an Open Circuit diver having a DCI incident full face masks would be utilised. All IWR equipment was to be set up and ready before for use prior to diving commencing, 100% Oxygen would be available both inside the cave and above ground.

It was also decided that there would be no recall procedures this was because divers would be locked into their individual dive/decompression profiles once they had committed to their dive plan, and as such would be autonomous from the surface.

Dives would be undertaken in several teams comprising of two or three divers, each diving similar profiles. Where possible these teams would be supported by other teams during their dive. However each team would be fully self-sufficient and self-supporting in its own right.

All divers had undertaken training in roped rescue and there were two Rope Rescue Instructors on site to co-ordinate and implement evacuation from water level inside the cave to the exit and above ground. A stretcher was available on site to facilitate such a rescue. Final evacuation from the site to a hyperbaric chamber would be by car to a standby aircraft, a Cessna Skymaster, the flight would be low level and follow cross border emergency protocols. The casualty would be flown back to Lanseria, Johannesburg for treatment, taking approximately 7 hours. DAN would be informed of the circumstances of the incident at the start of evacuation by other dive members via Satellite phone and a rendezvous point identified at Lanseria for the casualty to be transferred to the chamber and/or hospital.

I had arrived in Namibia a few days early having flown from Heathrow via Cairo and Johannesburg, to Windhoek. I took the time to explore the area before meeting up with Steph and Chris, the two Namibians who were the expeditions 'fixers'. They acted as the interface between the owners of Harasib Farm, Sarel and Leonie Pretorious, and expedition organisers; they were also responsible for rigging the cave, providing advice and assistance, and supplying a large quantity of support equipment. At 0430 hours on Saturday 4th July 2015, Steph, Chris and I left Windhoek and drove the 400 plus kilometres north to the Otavi Mountain Region. We eventually met up with the rest of the team up at Harasib Farm around 10.30 hours. A convoy of vehicles then drove to a location approximately 200m from the cave entrance; the rest of the journey to the cave entrance was out of necessity on foot. An enormous amount of equipment was then physically carried down an incredibly rocky path to the cave entrance, apart from the compressor, 50 litre cylinders of Oxygen and Helium, booster pump, solar panels, battery(s), and enough spares to stock a dive store, there was all the equipment to go down into the cave itself.

Over a ton and a half of equipment went into the cave, seven rebreathers, and three sets of open circuit scuba equipment, twenty nine stage cylinders, torches, reels and an enormous amount of personal dive equipment. It took a day and a half to get it in, and that was with the assistance of gravity, looking back now it was an incredible achievement, probably the most physically demanding thing I have ever done. There was no whinging or complaining, it had to be done, and the team did it, I get goose bumps just thinking about it.

We also laid a high pressure hose from the compressor on the surface to the platform in the cave below; in addition an electric cable was taken into the cave in order that we could use artificial lighting and also a telephone from the surface to the bridge.

What now lay ahead was five days of the most incredible diving ever.

Unfortunately however, that wasn't going to be the case for everyone, Karin had arrived at Dragon's with what appeared to be a viral infection, it got worse rather than better and fearing that she may be developing pneumonia she was evacuated from the site and flown back to South Africa.

In essence we split into three teams of three divers; Almero, Cobus and Michael; Charl, Bruce and myself, all of us diving on AP Inspiration Rebreathers; then Ian (on side mount) together with Stuart and Luke on open circuit. That left Don to supervise proceedings and when circumstances permitted to do his own thing on his rebreather. Andre and Alouette provided additional support, both inside the cave and on the surface throughout the expedition.

Day one's diving was about orientating ourselves to the cave environment, determining systems and procedures for preparing our equipment and kitting up, staging bailout cylinders at appropriate depths below the platform, and then an exploratory dive to familiarise ourselves with what lay beneath the surface.

All the rebreather divers were diving on Trimix; I carried a 3 litre 10/52 diluent, 3 litre 100% O_2, a redundant 5 litre 100% O_2, and two 11.25 litre (80cuft) bailouts of 11/58 and 18/48 together with an independent wing inflation system. Additionally I had access to 23/37, 50/20 and 100% O_2, staged below the platform and for use on deeper dives the team also had access to 9/67 bailouts.

On our first dive we remained within the main chamber which provided us with a continuous air space above at the surface, we tied off the reel to a Surface Marker Buoy and explored. Having descended close to the wall to the north of the platform we reached the bottom at about 46m, visibility was incredible limited only by the distance the beam of your torch would penetrate the darkness, the bottom seemed to be fine sand and there were huge boulders the size of houses as far as you could see. In between the boulders were large 'sand dunes', and valley's that appeared to have been caused by erosion. Directly below the platform, and hence the shaft leading into the cave, was an enormous dune, with its summit at 40m, the floor falling away all around it because of its size and position, became something of a landmark for us. We explored the bottom for approximately 25 minutes before slowly ascending below the platform and fulfilling our decompression obligation. During the mandatory one hour surface interval we prepared our equipment for the following day, and then slowly ascended the shaft to the surface.

That evening at supper we de-briefed the day's events, and discussed the following day's dive plans. Then unexpectedly Steph shook my hand and announced that I was the first 'Englander' ever to dive in Dragon's Breath, a revelation that called for a celebratory drink. In actual fact Don (Shirley) had dived there before and although born in England he was by then living in South Africa and holding dual nationality.

Dive two. Our intention was to position a large iron spike on the bottom in the vicinity of the dune below the dive platform, then tie off a reel and lay a permanent line to the beach. I descended to the top of the dune carrying the spike but my first attempt at placement was

met by solid rock about 3cm below the surface, I descended further to 46m and tried again, this time the spike pressed home right up to the reflective markers we had placed near the hook. The line was tied off by Charl and Bruce, and then with me navigating we set off towards the beach. We were initially surprised that rather than ascending we immediately descended to 63m into a valley running perpendicular to our path, it seemed to get deeper as it stretched out of sight to our left and away from the wall. We crossed the valley into a boulder field where there were a large number of angular rocks some the size of houses, some nestling together to form swim throughs, I remember thinking that this was what a Lunar landscape must look like, and then reflecting that considering our isolated location that we may as well be diving on the dark side of the moon. We continued towards the beach, tying off the line at appropriate locations and keeping the wall just within our sight on the right, we were ascending.

After about 35 minutes there was a change in the structure of the cave floor, we left the boulders behind and started to see speleothems, stalagmites and flowstone, this had to be the start of the beach. This was confirmed when we came across a metal bar driven into the substrate, whilst Charl and Bruce were tying off the line , I hovered above, mindful that I had over 15 minutes deco and my current ceiling was 15m. As I shone my torch around I glimpsed something reflective above and to my right, I indicated to the others, but knew we would have to wait out our deco before investigating further. We explored the beach area at 15m, 12m, and 9m, marvelling at the underwater formations, and in particular the stalactites penetrating the water's surface, which reflected a vivid blue in our torch beams.

Eventually we could ascend far enough to investigate what I had caught sight of in my torch beam earlier, it was a black metallic bat mounted in a circular frame onto a piece of reflective tape, next to it and on the other side of a stalemite was a plaque depicting four military badges and a number of inscriptions. I didn't know it at the time but, via the power of the internet, I would later speak to one of the soldiers responsible for putting it there, quite moving when I heard the story. After 93 minutes we surfaced, then we were met by another surprise, we were in the main chamber of Dragon's Breath, beneath a roof covered with a million or more stalactites, it was stunningly beautiful, utterly magnificent, we spent the next 45 minutes gently swimming on the surface, marvelling at what we saw before us, until we eventually reached the platform, then a three hour mandatory surface interval before we could exit the cave. By the time we got out it was dark, a recurring theme was developing.

That night I struggled to get to sleep the day's events kept replaying in my mind and I was absolutely buzzing, and just to compound the issue I was struggling to find a part of my body that I could lie on that didn't ache. Sleep eventually found me.

I woke the following morning with something tickling my ear, I was deep inside my sleeping bag and quite disorientated, then I realised it was Don trying to wake me, I had slept in, when I rolled over I gave Don quite a shock, I have sleep apnoea and wear a mask to maintain my airway when I'm sleeping, he wasn't expecting it.

After breakfast we were back down the hole for dive number three, scrubbers re packed and cylinders re filled we started to assemble our equipment, Charl had a problem with his scrubber which ruled him out of the dive, so it was just Bruce and I. Our plan was to head in the opposite direction to the beach and explore an area of the cave that was as yet uncharted. We descended to the spike and tied off the reel, initially we got the direction slightly wrong, but soon recovered the situation, unfortunately the line slipped off my reel whilst reeling in, I

was unable to resolve the problem, so tied on a second reel and finned over the dune before descending along a steepening slope through huge steps created by the boulders. All too soon we were 45 minutes into the dive and had 85 minutes deco to complete, we found a superb tie off where a rock was wedged between two boulders, cut the line and headed back to the platform collecting my tangled reel on route, we also found an old equipment bag, it had a tag on it which read Charles B13, it had probably been lost by Charles Maxwell in July 1987, when he was a member of the first team of divers to dive in Dragon's Breath. After 130 minutes we exited the water for another three hour mandatory surface interval. Once again we exited the cave in the dark.

Next morning we adopted the usual regime, packing scrubbers, filling, checking and analysing gas, then hauling everything down through the cave to the platform. Today it was Bruce's turn to have a problem, somehow his drysuit had ended up under a pile of equipment in the bottom of an inflatable, and it was soaked, we were planning our deepest dive to date with the longest decompression obligation, Bruce was going to have to give it a miss.

Charl and I set off, we descended quickly to the line I had laid the day before and we soon reached the tie off, I tied off my primary reel and we continued our descent. We were descending quickly, huge boulders interspaced with sandy gullies providing a giant's staircase into the depths of the cave; we passed 100m, quickly acknowledged the fact then started to look around for somewhere to tie off the reel. There was nothing immediate so I ascended slightly and tied off the reel at 99m 16 minutes and 30 seconds into the dive, I left the reel in situ intending to continue our exploration the next day. We had a lot of deco to do, 2 hours 15 minutes to be precise.

I got cold, the water temperature was 24 degrees Celsius, two degrees less than expected, my 5mm wetsuit just didn't provide me with sufficient insulation for that length of dive, I started shivering on the line and just couldn't seem to stop myself, not for long anyway, and when I did I could feel Charl shivering in his wet suit too. Out of the water I continued to shiver, Almero produced a space blanket and the guys wrapped me up like a Xmas turkey. I began to sit out my mandatory three hour surface interval before exiting the cave; fortunately I stopped shivering and warmed up.

Once out of the cave I spoke to Don, we both knew that I was not going back for my reel in the morning; I could dive but needed to keep the decompression to a minimum, and avoid getting cold again. Charl had his drysuit with him so he would be OK.

Unbeknown to me, whilst I had been tying off my reel on our dive, Charl had ascended slightly and caught sight of another line running parallel to ours and not too far away, this would become significant later, when it was discussed at the de-brief that evening. During the summer of 2011 two divers, Johnny Martinez (aka Johnny Bravo) and Philippe Marti had made a record dive to a depth of 105 m in Dragon's Breath Cave. The line Charl had seen was the one laid by Johnny Bravo.

Our last dive day arrived far too quickly. Charl and Bruce both diving in drysuits were going to pick up my reel from the previous day and extend it to link up with Johnnie Bravo's line, they were then going to mark it with a light so that Almero, Cobus and Michael could extend that line even further. My plan was to return to the beach, and extend that permanent line right up to the plaques.

Once everyone was in the water I kitted up, entered and descended to the spike where I picked up the line to the beach, it was easy to identify because I had marked both permanent lines with cookies. I followed the line into the valley but took my time and began to explore in and around the boulders on either side, looking back I could see the other divers' lights as they returned from their dives to complete their deco. I was acutely aware that I was diving solo, all my senses seemed heightened and yet I felt very relaxed and at ease. I continued to the end of the line, then attached and tied off the only line I had left, a finger spool. I ran it out to within 5m of the plaques; I tied off, cut the spool free, and spent the rest of my dive exploring the beach area. It was just as amazing the second time, having the time to take in more of my surroundings I found some amazing speleothems, stalagmites, stalactites, flotsam, columns and soda straws. I still managed to rack up 10 minutes deco but this time and more was spent exploring the shallows. Again the surface swim back to the float was just amazing and I was joined by Don and Andre who had gone for a swim.

Back at the float the other divers were still fulfilling their decompression obligations; I exited the water, spent my one hour mandatory surface interval sorting out my dive gear then climbed out of the cave, and for the first time in five days saw the sun setting over the bush. It didn't last long because before I knew it I was back in the cave starting the process of bringing out the gear. It was to be another late night.

Back at the farm, the braais was lit. During the de-brief we discovered that, Almero, Cobus and Michael had followed their dive plan, all three had dived deeper than anyone had been before in Dragon's Breath, with Cobus reaching 131m (equivalent to over 162m at sea level) and that definitely called for a celebration.

The following morning we had a lie in, well sort of, then it was back into Dragon’s and several hours of intense physical exertion bringing out everything we had taken into the cave, this time however gravity was against us. Eventually after another massive team effort, the cave was clear, ropes removed and ‘bakkies’ loaded.

On Saturday morning several members of the team left early, the remainder stayed behind in order to explore another cave, Harasib; 2.4 km from Dragon’s on a bearing of 23 degrees, the entrance is at an altitude of 1643m, and 112m below, at the bottom of a shaft lies another mostly unexplored large subterranean lake.

Sat at the bottom of the shaft looking out over the lake at more spectacular cave formations I reflected on my incredible adventure, this was by far the most physically demanding and challenging thing I had ever done in my life, but also the most rewarding in so many differing ways. Huge sections of both Dragon’s and Harasib lay unexplored presenting untold new challenges to future expeditions. I was the first to put my name down for the next one, can’t wait to get back.

Summary:

Seven days at Dragon’s Breath Cave, Namibia

Two full days to set up and break down
1.5 Ton of equipment taken into the cave, and later removed, including:
7 Rebreathers
3 Open Circuit
29 Bail Out Cylinders
Ancillary diving equipment
5 Boats, 3 Tubes and 1 Platform
2 Dragons
Accumulated time underground 831 hours

Five days diving

Accumulated dive time 79 hours 07 minutes
Maximum depth 131m – deepest ever dive in Dragon’s Breath
Six divers dove beyond 100m
Several life forms identified not previously known to inhabit the cave

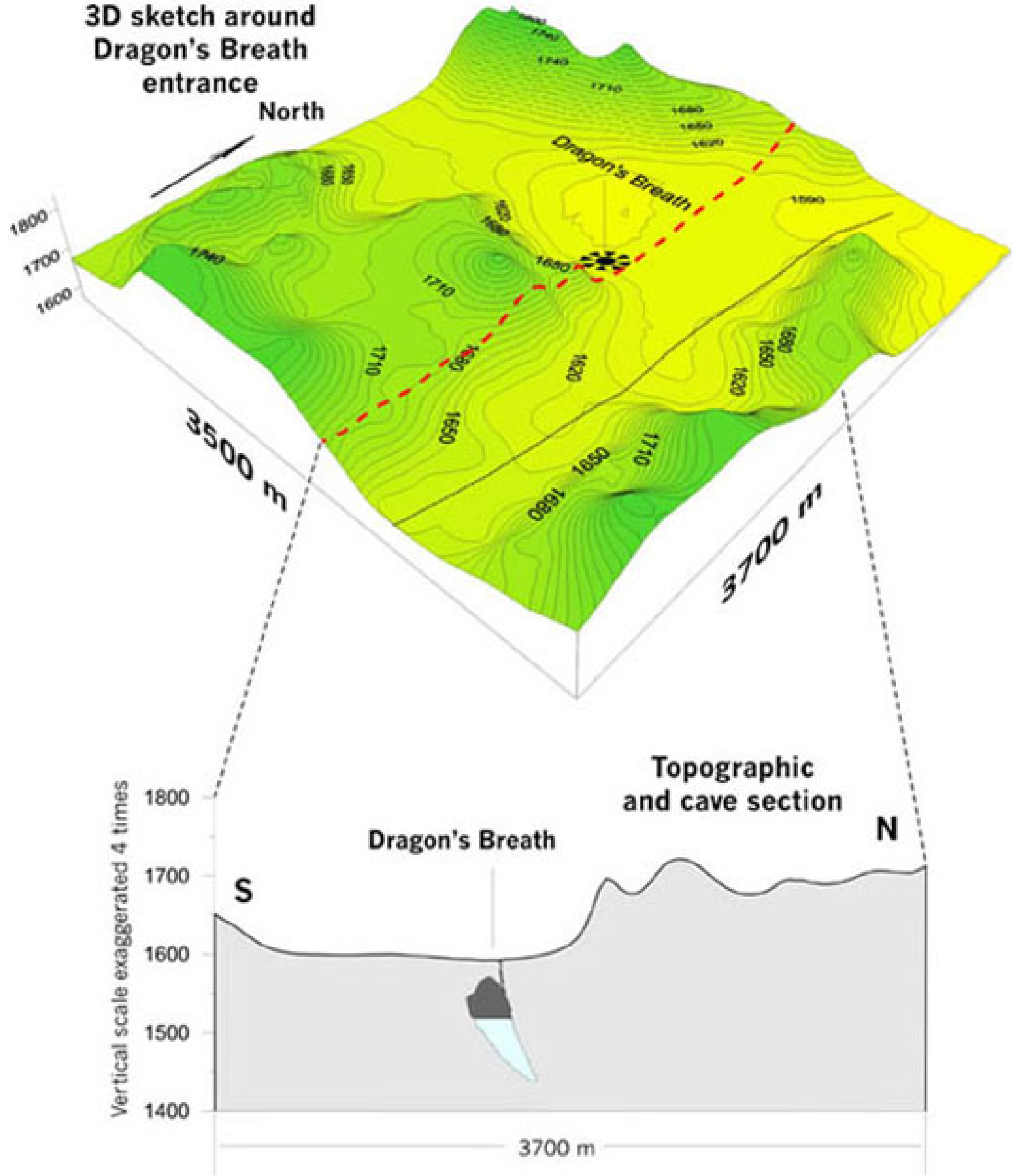
One day exploring Harasib Cave, Namibia

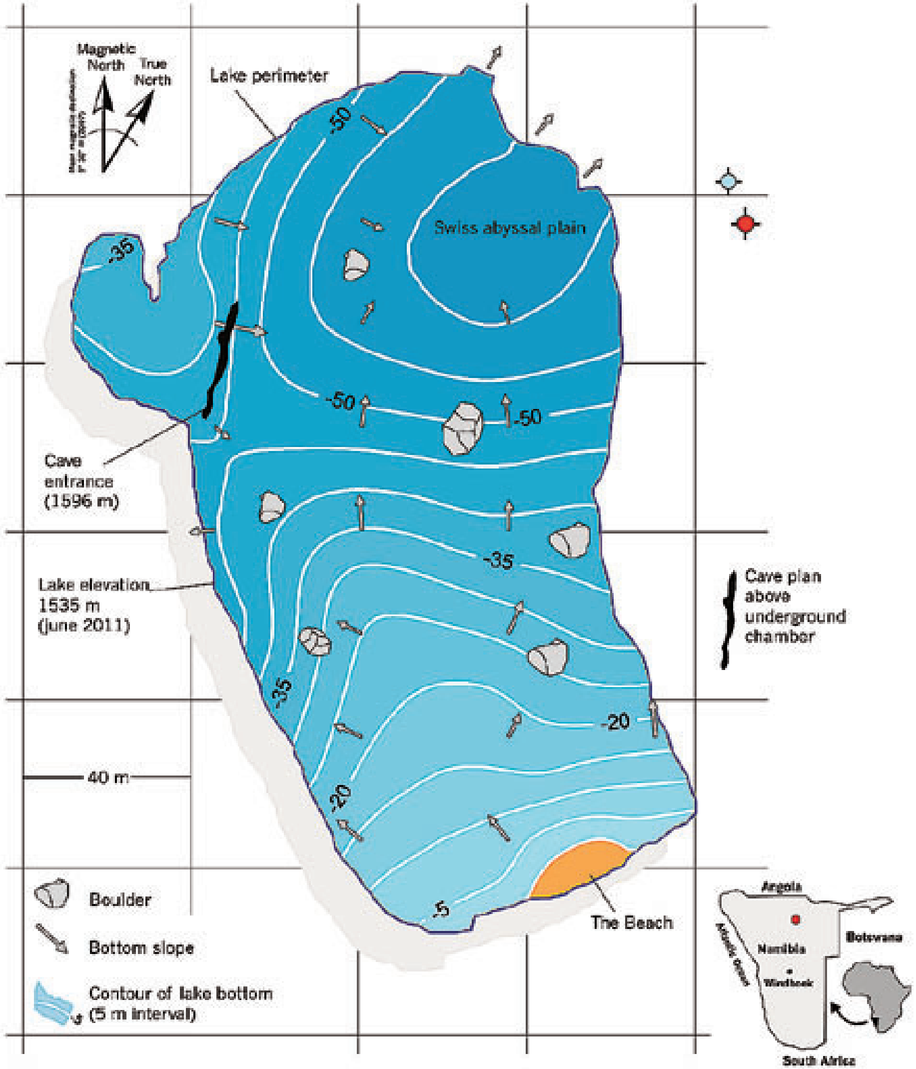
The expedition team comprised: (15)

Don Shirley	Andre Shirley	Andy Sargent
Almero Retief	Cobus Briel	Michael Yeates
Stuart Hynes	Luke Hynes	Charl Mostert
Bruce Barker	Alouette Barker	Ian Koegelenberg
Chris Steenkamp	Steph Viljoen	Karin Human

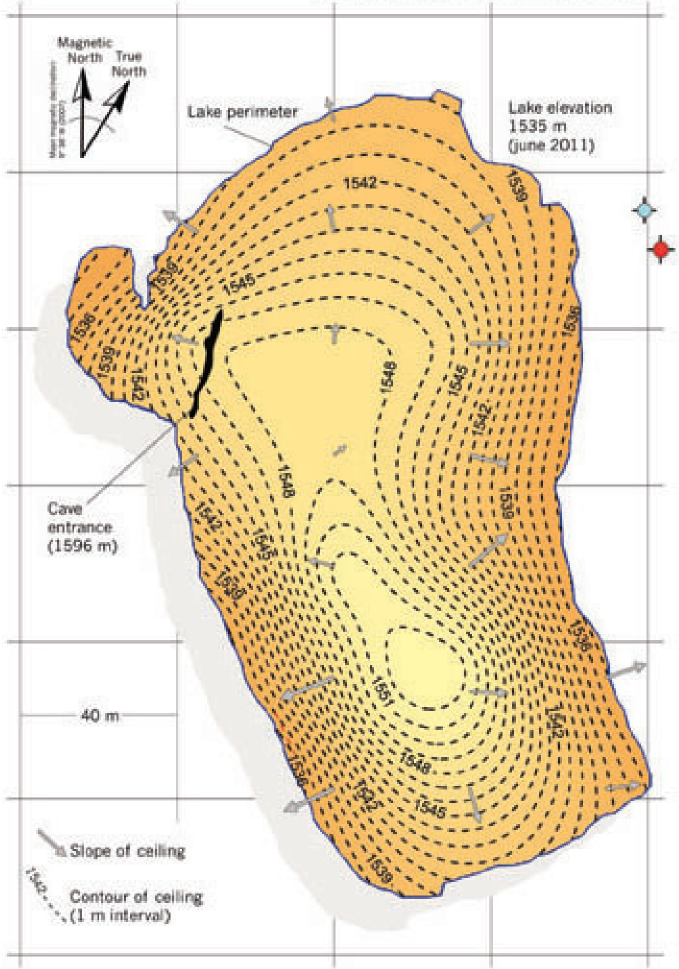
Note:

The BBC Documentary ‘Africa’ narrated by David Attenborough is incorrect, the blind fish Clarias Cavernicola referred to in the documentary do not exist in Dragon’s Breath Cave, rather they do inhabit Aigamas some 40km to the west, furthermore the abseil descent featured in the documentary is actually into Harasib Cave which is 2.45km from Dragon’s Breath.

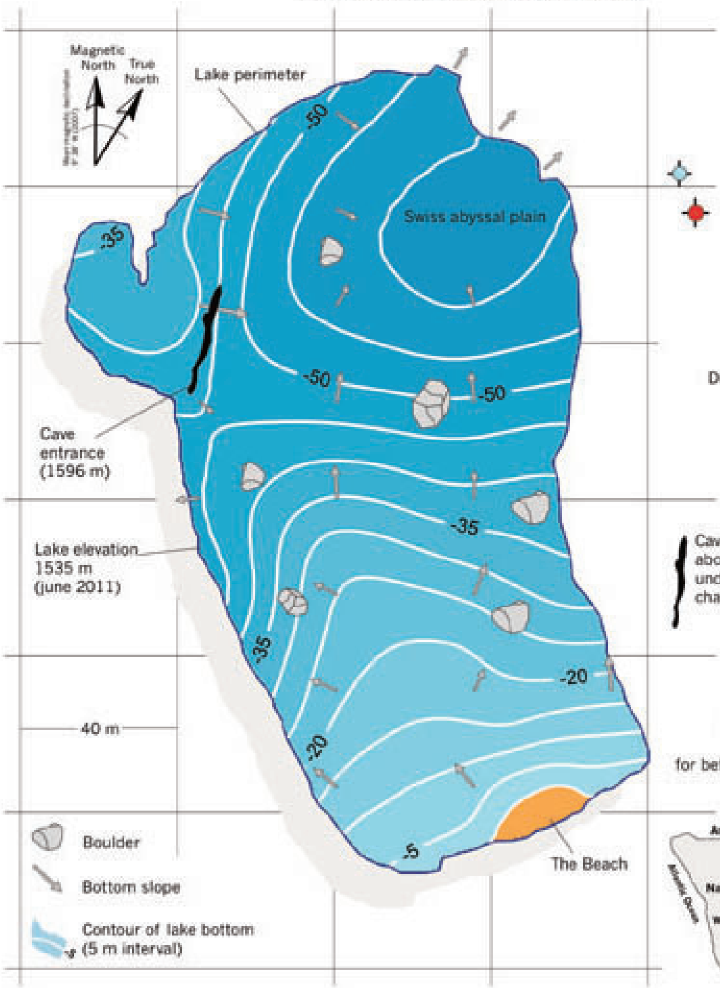

3D sketch around Dragon's Breath entrance
North
Dragon's Breath
1800
1700
1600
3500 m
3700 m
Topographic and cave section
Dragon's Breath
S
N
Vertical scale exaggerated 4 times
1800
1700
1600
1500
1400
3700 m


Magnetic North
True North
Lake perimeter
Swiss abyssal plain
-35
-50
-50
-50
-35
-35
-20
-20
-5
Cave entrance (1596 m)
Lake elevation 1535 m (june 2011)
Cave plan above underground chamber
40 m
The Beach
Boulder
Bottom slope
Contour of lake bottom (5 m interval)
Angola
Namibia
Botswana
Windhoek
South Africa

Contours of lake's ceiling

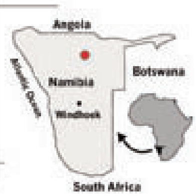


Contours of lake's bottom



Cave plan above underground chamber

See also topographic profiles for better comprehension



Namgrows 2011
Euro African Caving Expedition
(Otavi Mountains, Namibia)

Dragon's lake
Ceiling and bottom plans
(Harasib farm)

Caving groups:

Societé Spéléologique Genevoise
G.S. CAI, Vittorio V.
G.S. Arianna Treviso

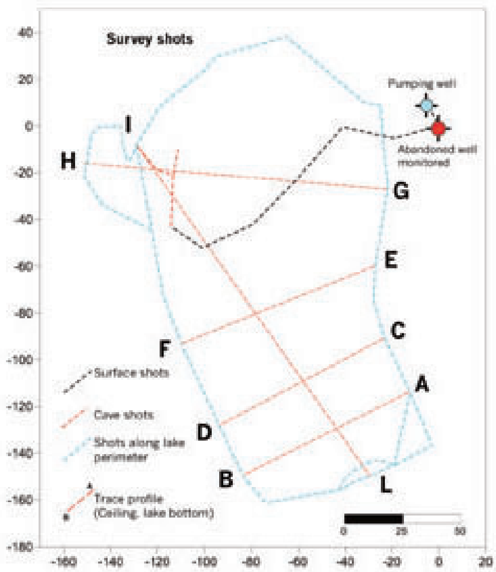
Partners:
STS-Italia
Cave Diving Commission (S.S.I.)

Namgrows 2011:

Berclaz Vincent	Martinez Johnny
De Mori Michele	Monney Frederic
Bouffartigue Nathalie	Pretorius Hannelie
Favaro Andrea	Pretorius Leonie
Favre Gérald	Pretorius Eleonore
Favre Robin	Rufi Christian
Fileccia Alessio	Shirley Don
Kilchmann Sybille	Steenkamp Chris
Lacante Sarel	Van Eeden Theo
Marti Philippe	Viljoen Steff

Date and survey: june 2011 by Fileccia Alessio
Precision of survey: BCRA 5/C
Lithology: calcareous dolomite
Lake perimeter: 626 m;
Lake extension: 18348 sqm (june 2011)
Lake extension: 26080 sqm (Namibian expedition 1991)
Lake level in september 2010: -68,12 m from abandoned well
Lake level in june 2011: -61,6 m from abandoned well
Max depth attained: -105 m below lake surface
(J. Martinez, P. Marti, june 2011)

Dragon's lake chamber from The beach (A.Favaro)



Pressure Variation with Temperature Change: Old PADI IDC Method vs. Ideal Gas Law

By Julien Fortin

Following article is about how to calculate the pressure variation in a SCUBA cylinder when the temperature of the cylinder changes: the method given in some scuba textbooks and PADI's old Instructor Development Courses (IDCs) exams provides slightly different results than the calculations derived from the Ideal Gas Law. This article intends to demonstrate how the PADI Approximation and the Ideal Gas Law are related, and why the two methods are almost equivalent.

PROBLEM

Following discussion is about how to calculate the pressure variation in a SCUBA cylinder when the temperature of the cylinder changes.

* In old IDC exams, PADI tells students to base calculations on a 0.6 bar increase or decrease in pressure for each 1ºC variation of the temperature of the tank. In other words: delta P = 0.6 x delta T

* The Ideal Gas Law, on the other hand, states that PV = n.R.T. Since n.R is constant, and the volume of the tank is a constant as well, it means that P1/T1 = P2/T2, or, in other words, that: P2 = P1xT1/T2, or delta P = P1- P1xT1/T2

Depending on whether we use the PADI approximation (delta P = 0.6 x delta T) or the Ideal Gas Law (delta P = P1- P1xT1/T2), we'll find slightly different results for the pressure change resulting from temperature change in a tank.

This article intends to demonstrate how the PADI Approximation and the Ideal Gas Law are related, and why the two methods are almost equivalent.

DEMONSTRATION

1. Ideal Gas Law

The Ideal Gas Law states that P.V = n.R.T, where

- P is the absolute pressure, in bars or atm
- V is the volume, in liters
- n is the amount of moles of gas (knowing that the number of atoms or molecules in one mole of a substance is equal to Avogadro's constant, or 6.023×10^{23})
- R is the Gas Constant, in $L.atm.K^{-1}.mol^{-1}$
- T is the absolute temperature, in ºK (knowing that ºK = ºC + 273)

The number of molecules of gas does not change in a cylinder when I increase its temperature (n is constant) - and the Gas constant is, by definition, a constant.

If PV = n.R.T, it therefore means that P2-P1 = n.R.T2/V-n.R.T1/V, which is equivalent to: delta P = n.R/V x (T2-T1) (1)

This looks more like the PADI approximation - but we need to calculate the numerical value for n.R/V.

2. Quantity of gas in a cylinder (i.e. amount of moles) and Standard Molar Volume

The trick for doing so is that the amount of moles in the cylinder will naturally depend on the pressure - and hence, when considering a scuba cylinder with a fixed volume, on the pressure inside that cylinder.

Let's just assume that we usually work with full AL80 cylinders, i.e. 200 bars in a single 11.88 liters cylinder, which is to say an uncompressed volume of 11.88 x 200 = 2376 L.

You probably remember from your school days that the Standard Molar Volume is 22.414 L/mol, which means that for any given gas, 1 mol of this gas will take 22.4 liters at 1atm - but this is only valid at Standard Temperature and Pressure, which is to say at 0ºC, or 273ºK. The amount of molecules, i.e. moles of molecules in the cylinder is however determined when the cylinder is filled. Due to the heat of compression, the temperature inside a cylinder during the filling process can easily reach around 60ºC, or 60+273 = 333ºK. We therefore need to know what the Standard Molar Volume (SMV) would be at a temperature of 333ºK.

Charle's law states that the volume of a given mass of gas is directly proportional to its temperature on the absolute scale when the pressure is held constant. In other words: V1/T1 = V2/T2 if the pressure is constant.

Knowing that the volume of gas is given by: V = SMV x n, where n, the number of moles of gas, is constant if I don't change the quantity of gas in my cylinder, and SMV the Standard Molar volume, it follows that: SMV1/T1 = SMV2/T2.

The Standard Mass volume at a given temperature t in ºK (SMVt) will therefore be: SMVt = (22.414 x t) / 273 (2)

Using equation (2), I can therefore calculate SMV333 = 22.414 x 333 / 273 = 27.34 L/mol.

At a filling temperature of 60ºC, or 333ºK, each mole of gas will occupy a 27.34 L at a pressure of 1atm (approx. 1 bar). The amount of moles in my cylinder can thus be calculated as follows:

n = V / SMV = 2376 / 27.34 2376 = 86.9 mol.

I therefore have approximately 86.9 moles of gas in a standard AL80 scuba cylinder filled up to 200 bar at an inside filling temperature of 60ºC.

As for the Gas Constant, we need to express it in $L.atm.K^{-1}.mol^{-1}$, and not in the usual $J.K^{-1}.mol^{-1}$ sometimes used in physics text books, since we work with volumes in liters and pressure in bars or atm. I'll use $R = 0.082057338\ L.atm.K^{-1}.mol^{-1}$.

3. Calculation of the pressure variation ratio for temperature changes

Now that we have the 3 numerical values for the number of moles of gas in the cylinder (n), the Gas Constant (R) and the volume of the cylinder (V), we can calculate the value of n.R/V:

n.R/V = 86.9*0.082057338/11.88 = 0.6

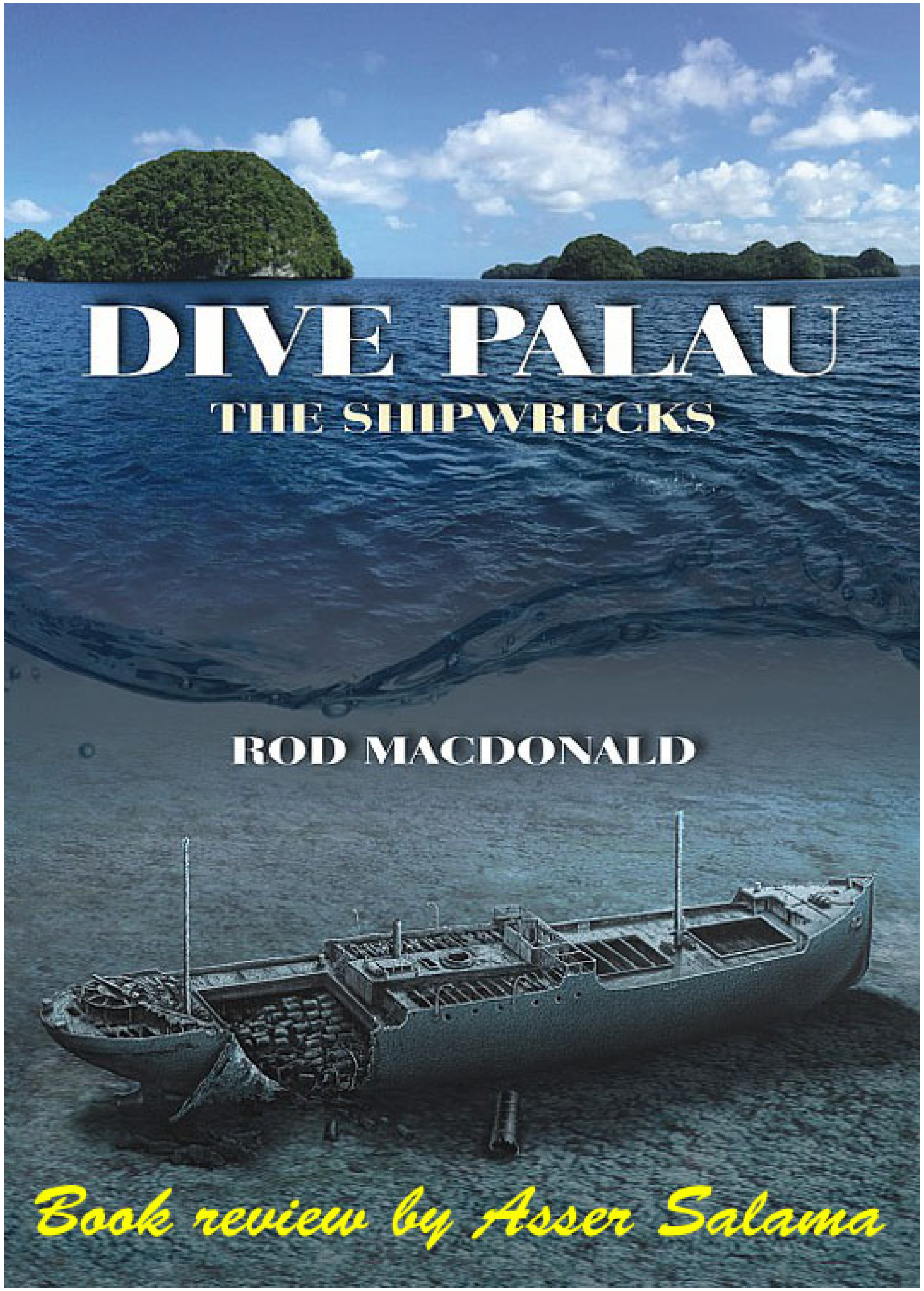
If we insert this value into equation (1), we obtain: delta P = 0.6 x (T2-T1)

Which is the PADI approximation method - and looks like magic.

CONCLUSION
Both methods are equivalent, and based on the same physical laws: the Ideal Gas Law, Charle's law, the relationship between volume and the quantity of gas, etc.

The method based on the Ideal Gas law tends to be more accurate, as it does not depend on the volume of the cylinder or the filling temperature, while the old PADI method offers an approximation based on a standard size of cylinder (11.88L), and a standard filling temperature (60ºC). The advantage of the PADI method is that it makes the calculation slightly simpler, since it does not require the student to understand or remember the Ideal Gas Law, and gives an approximation which can easily be applied in the field.

What you use is up to you, as both methods are somewhat equivalent. I tend to use the Ideal Gas Law method (delta P = P1- P1xT1/T2), as it seems very logical to me - but if you need a quick fix for on-the-fly calculations using only AL80 cylinders, or if your only goal is to pass a theory exam, and hence to find a value that matches a Multiple Choice Answer, then you could definitely use the approximation (delta P = 0.6 x delta T).



This book reveals in great detail how Palau was neutralized as a Japanese naval and air base. As a history enthusiast, Rod Macdonald provides an exciting account on Operation Desecrate 1, the raid undertaken to destroy Japanese ships and aircraft in the lagoons of Palau. As a diver and an explorer, he catalogues how the 20 major Japanese WWII shipwrecks look today. Detailed text along with illustrations and underwater photographs take the reader on a stimulating journey.

Moreover, Rod describes the research efforts he has done to identify the "Helmet Wreck". Pretty interesting to say the least.

Dive Palau: The Shipwrecks comes in 303 pages and is published by Whittles Publishing.