Tech Diving Mag

Research - Development - Exploration

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Issue 2 – March 2011

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Front cover image © Espen Indbjør.

Editorial

Welcome to the second issue of Tech Diving Mag.

The inaugural issue was a great success. It has been downloaded more than 5,000 times in three months. The Facebook page attracted more than 730 fans, and still growing.

This success motivates me to continue searching for quality articles. In this issue of Tech Diving Mag, the contributors have brought together a wealth of information on some of the most interesting topics of technical diving. The contributors for this issue are world renowned industry professional Bret Gilliam, famous technical instructor trainer and writer Steve Lewis, diving instructor and entrepreneur Alberto Mantovani, along with underwater explorers Jorge Russo, Brent Hudson and Brian Matthewman. Read their full bio at www.techdivingmag.com/contributors.html.

Tech Diving Mag is very much your magazine and I am keen to have your input. If you have any interesting articles, photos or just want to share your views, drop me a line at asser@techdivingmag.com.

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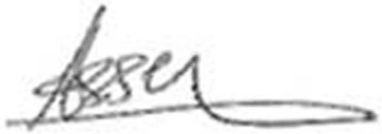
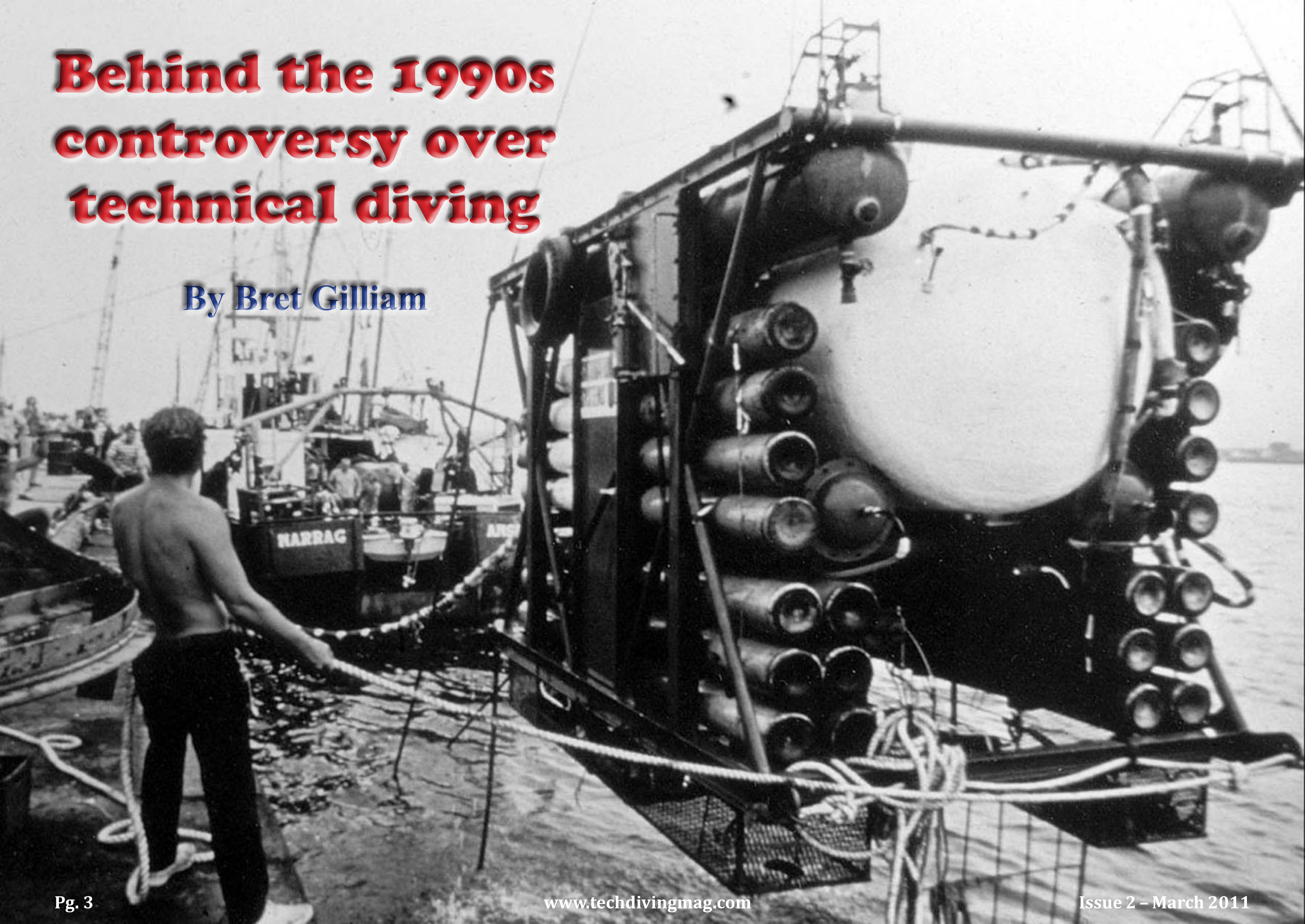


Asser Salama
Editor, Tech Diving Mag

Behind the 1990s controversy over technical diving

By Bret Gilliam



My inaugural editorial on the origins of technical diving that appeared in the first edition of Tech Diving Mag struck a nerve with a lot of readers who seemed to appreciate the "behind the scenes" look at how a lot of the deep, wreck, and cave diving practices got started in North America. As I noted in that piece, most of the early divers who went down these paths came from very experienced backgrounds including military, commercial, and scientific diving disciplines that they applied to their later explorations and interests in the mainstream diving community.

And initially, most of their pioneering work was kept within a small cadre of select divers (who vetted each other's skills and protocols), primarily over concerns that less experienced persons would injure or kill themselves attempting dives vastly beyond their capabilities, experience, and training. Remember that back in the 1960s and 1970s just communicating information could be difficult. There was no Internet, no email, no way to quickly search information such as "Goggle" or "Wikipedia". Hell, the fax machine hadn't even been invented yet! So if you wanted to make an inquiry about physiology, dive tables, medical contingencies, or details of equipment outfitting you had to write what was known back in that era as a "letter". I know, I'm dating myself (I just turned 60 in February, gasp!) but it's important to emphasize the information vacuum that most of us had to deal with in those prehistoric times. For those of us living and working in remote areas such as the Caribbean, even phone calls were problematic. Either the costs were prohibitive or you simply couldn't access a phone in some places at all.

By the early 1970s, annual diving conferences sprang up around the country and lively discussions took place as most of us traveled to attend and make formal presentations on what we were doing in our own little niches. These infrequent get-togethers were the basis of information sharing, detailed analysis of what was working for us in technique, equipment, breathing gases, dive tables, and tons of other exchanges that took place face-to-face when we crossed paths. This was my first chance to meet guys like Tom Mount, Sheck Exley, Glenn Taylor, Howard Hall, Douglas Faulkner, Bob Hollis, Stan Waterman, Ron & Valerie Taylor, Jack McKenney, Ron Church, George Benjamin, Dick Anderson, Dick Clark, Morgan Wells, Dick Rutkowski, and a handful of other innovators across the world who would stumble into each other every year or so at some workshop held in Miami, San Diego, Chicago, New York, Toronto, or Boston. Of course, the sponsors of these programs were looking to attract the everyday diver and instructor but our off-the-wall presentations kept things lively and stimulated ticket sales. But most of the mainstream diving public pretty much considered our ilk as intelligent and highly skilled... but totally insane.

Peter Gimble, Valerie & Ron Taylor, and Stan Waterman ready for a dive with sharks filming "Blue Water, White Death" in 1969

As I mentioned in the last issue, our type of “advanced diving” didn’t really have a name unless you just attached “explorer” to our various activities. And we were largely treated with deference and respect since we were off into things that hardly anyone else dared to attempt. For those of us who also were writers and photographers, our work was frequently featured in the small circle of diving magazines that existed then and reached a worldwide audience. Others produced excellent short films that thrilled diving audiences and later proved a stepping stone to Hollywood movies, television, and documentary work. A handful of us had books published and these helped tremendously to spread information in more expansive detail.

Andrea Doria **wreck pioneers Bob Hollis and Al Giddings today**

Consider for a minute some of the incredibly challenging diving that was going on. Peter Gimble dove the wreck of the ***Andrea Doria*** less than 24 hours after it sank in the mid-1950s and got photos on the ship lying on the bottom that ended up on the cover of Life magazine. Al Giddings was part of a movie team that went back in the mid-1960s to chronicle the wreck in far greater detail. His team used alternate gas mixes, oxygen for accelerated decompression, dealt with on-site decompression sickness emergencies, and pushed the envelope way beyond what any deep wreck explorers had done at that point. In 1969 Gimble was back with the financing to shoot the definitive documentary on sharks, “Blue Water, White Death”. He enlisted veteran stalwart Stan Waterman and Ron & Valerie Taylor, Australia’s leading diving pioneers and shark experts.

From the outset, Gimble laid out his agenda that called for unprecedented up-close encounters with sharks including the Great White. This full length movie fascinated the public with deep wreck sequences, out-of-the-cage jaw-dropping segments with feeding pelagic oceanic white tip sharks in the open sea... at night! And finally wrapped up with the first ever “in your face” footage of Great Whites doing their best to destroy the metal protective cages and the divers inside. Peter Benchley later noted that this film was part of his inspiration to write “Jaws” a few years later. “Blue Water, White Death” was also nominated for an Academy Award for Best Documentary movie.

George Benjamin, Tom Mount and others did the first penetrations into the Andros Blue Holes and their seemingly endless cave labyrinths while Sheck Exley literally wrote the book on inland cave diving while pushing ever deeper and farther than anyone had ever gone before. Hal Watts, Dr. Bob Dill, Mount, and myself all blew away supposed limits in deep diving that proved to be entirely theoretical and not based in actual human tolerances and capabilities. By employing innovative applications of equipment, modified decompression models, higher oxygen PO2 windows, and techniques to minimize narcosis, we routinely worked nearly to 400 feet (122 meters) on air for commercial, scientific, and filming projects.

The most elaborate diving expedition of all involved Bob Hollis and team that (ironically) included Skindiver magazine's assistant editor Jack McKenney as they rigged a tiny support habitat called "Mother" to the sunken ***Andrea Doria*** wreck in 1973 and then proceeded to use saturation protocols to go after what riches might be found in the various safes and jewelry depositories that went down with the ship. Hollis ended up on the cover of Skindiver as he used an underwater cutting torch to burn an access hole into the ship's port side while on an umbilical hose from the habitat. (Twenty years later Skindiver would become the chief critic all things in technical diving and technology breakthroughs like diving computers. And it would ultimately lead to their bankruptcy.)

Pretty heady stuff... It fascinated the public and entranced the diving industry. Some years later in 1988 I changed all the paradigms of the time by launching a 550-ft. (168-m.), 28,000 ton cruise ship as part of the Ocean Quest International fleet that catered to divers in ways previously unimaginable. We did our diving in the Mexican Yucatan, Belize's atolls, and the Bay Islands of Honduras. Ten custom 36-ft. (11-m.) dive boats were launched daily offering up to seven dives a day... with no limits to depths, bottom times, or decompression. Even solo divers were welcomed. Diving computers were provided to guests along with the first certification programs in such devices. Nitrox was available and we had our own full sized multi-place, multi-lock recompression chamber onboard. We averaged over 1200 dives per day by our guests and staff. It was then, and remains, the largest diving operation in the sport's history.

Bob Hollis in saturation habitat "Mother" moored at 180 feet (55 meters) to the *Andrea Doria* wreck

Captain Bret Gilliam running ship's recompression chamber during deep diving projects, 1989 (photo by Lynn Hendrickson)

Suddenly, we turned the corner on the 1990s and a peculiar mood began to intrude on diving. I still look back now some 20 years later and am amazed at some of the nonsensical attitudes that tried to squelch anything innovative or new that came forward from the self-appointed "guardians" of diving's old school. If you weren't around then to remember the incredible controversies that abounded over anything associated with technical diving, nitrox, or even how many dives a day was considered allowable, let me take you in my little "virtual time machine" and revisit the era when a segment of arch-conservatives tried to hijack diving's future with their neo-Nazi heavy-handed tactics. Brace yourself...

Dick Rutkowski was the first target. When he retired as NOAA's Deputy Director of Diving, he decided to expand his cutting edge training programs on recompression treatments and chamber operations to include the first formalized training in nitrox. Nitrox had been around for two decades but was largely limited to commercial and science diving applications. But Rutkowski saw the huge benefit for sport divers to lengthen no-decompression windows and allow more dives per day by shortening surface intervals. The advent of the first reliable dive computers also signaled a future for divers to program selected O2 mixes for optimum dive efficiency.

But you would have thought that he suddenly came out in favor of child molestation in the response he received from the conservatives. DAN's executive director Peter Bennett condemned him as an irresponsible reprobate who should be thrown out of diving professionally. Skindiver magazine's editor Bill Gleason ran a sensational editorial referring to nitrox as "the Devil's Gas". PADI and SSI proclaimed that nitrox had no place in recreational diving. I was on NAUI's Board of Directors at the time and suggested that NAUI lead the way and get behind the new technologies such as nitrox, dive computers, and technical diving in general. My perspective fell on deaf ears so I joined with Tom Mount and Billy Deans to expand Rutkowski's International Association of Nitrox Divers (IAND) and widen our curricula as the International Association of Nitrox and Technical Diving (IANTD). We were immediately branded as the equivalent of heretical witches and targeted as leading the whole industry on a path to destruction.

In a way, it was kind of amusing. People that has already "been there, done that" like Giddings, Waterman, Exley, Hollis, the Taylors, would occasionally check in to see what bombs were being lobbed in our direction but all simply advocated getting the information out there for the public to make an informed choice. Mount, Rutkowski, and I became the designated spokespersons for much of the technical community in endless rounds of dive show presentations and workshops. At times even the opportunity for an equal chance to reach the public was denied. The 1993 DEMA Board briefly voted to ban all exhibits for nitrox and technical diving training and products. This was swiftly withdrawn after we had a legal dialogue on things like "restraint of trade" and "tortious interference in business". So all was reinstated in time for the 1993 trade show.

The Cayman Islands Watersports Association banned any nitrox training or use, banned dive computers, decompression diving, and instituted a rigid "dive in a group" protocol where all divers were herded together with divemasters in the front and back to enforce strict depth limits (nothing deeper than 100 feet – 30 meters) and bottom times. Only two dives per day were allowed and anyone who dared to protest was designated a "rogue diver" who could be thrown out of a resort with no refund. When I was invited by a group of instructors to come down in 1992 and conduct a seminar on nitrox and recompression treatment, I was threatened with arrest if I dared to show up. (I did anyway and nearly 100 divers turned out for my

Bret Gilliam during "beta-testing" of new UWATEC diving computer models in Belize, 1992

program. The local police did stop by to tell me that they had received complaints but that this was not something they were going to get involved in. And since I was filling up an entire hotel with paying customers, they wished me well and said come back any time. The Watersports Association was furious but impotent to do anything but snipe and wish they were getting some of fees that I amassed that week.)

In early 1994, I departed IANTD and formed Technical Diving International (TDI). This quickly became the largest technical training agency in the world. I was also by then the Chairman of the Board of NAUI and reached out to other prominent and credible diving professionals to bring the message of the newer technologies to as wide an audience as possible. But it still seemed incredible to us that anyone with an IQ above room temperature could not see the benefits of nitrox, diving computers, modern rebreathers, and the establishment of proper training programs to ensure that divers had the chance to get educated properly. In late 1995, I took over UWATEC as Vice President and CEO and began yet another parallel business expansion in manufacturing diving instruments, computers, and rebreathers. Business was booming for me. (In 1997, UWATEC was taken public in a sale worth almost $47 million.)

Finally, the real reasons for all the bomb-throwing began to become clear. It was about the conservatives' mistaken opinions about their supposed influence and ability to control the industry. Boiled down to its essence, it was about power and magazine ad sales. I was involved with Fred Garth in a magazine called Scuba Times that prided itself on appealing to an active diver demographic that was eager for reporting on the latest innovations. When we added a section called the Advanced Diver Journal that reported on nitrox, computers, custom tables, technical diving, etc. we were threatened by some prominent operators in the Caymans and Bahamas with cancellation of all their ad placements if we didn't immediately shut down such perversity. It took us about ten minutes to tell them to go stuff themselves. Meanwhile, a new magazine jumped on the national scene called Rodale's Scuba Diving in early 1995 as a well funded and direct competitive threat to Skindiver's bombastic editorial policies (all technical diving was evil and anyone that bought an ad for anything was termed "world class"). Journalistic ethics had gone completely out the window. It was about who paid for ads... and that financial clout bought you raving good reviews and a role in restricting anything else if you didn't like what other divers were doing. It was a business model dreamed up by morons who actually believed that an entire world of diving sports participants could be blatantly lied to and manipulated with deliberately false information. A favorite joke of the time was: "How can you tell when a Skindiver writer is lying? Their lips are moving!"

Skindiver's reign as the #1 diving magazine was in peril. I was retained from the outset as the Senior Technical Editor for Rodale's Scuba Diving and given carte blanche to write about anything I wanted. Skindiver responded with a headline editorial that referred to their sacred depth limit of 130 feet (40 meters) as the "Red Line of Death". According to Skindiver, technical diving and nitrox along with diving computers would doom the industry and kill all the unsuspecting divers who read our irresponsible articles. A duel of the two magazines ensued... a literal battle to the death. It really didn't last very long.

Because it seems that the diving public was a lot smarter than Skindiver and their henchmen understood. When accurate articles with proper information were published the divers voted with their wallets and decided to take nitrox and technical training, buy diving computers and newly designed gear like streamlined back-mounted BCDs, enlarged volume cylinders, and other products that just made sense to a diver's ability to maximize their enjoyment of the sport and their safety.

The naysayers were really never good about their distortions of the truth since both science and physiology contradicted them at every turn. Skindiver lost all credibility and ad sales tanked since

Bret Gilliam gives presentation on new rebreather models for TDI, 1994

readers finally figured out that they could hardly believe anything that was printed since it was so totally tied to ad sales. Meanwhile, manufacturers, resorts, liveaboards, and training agencies realized that all this new technology was good business. And they shifted their support to other publications to reach the audience the wanted to sell to. And that audience wasn't reading Skindiver anymore as they continued to rant about nitrox and writing an endless stream of glowing articles about past-their-prime Caribbean and Florida diving while calling it all "world class".

The whole house of cards tumbled down in 1997 when PADI finally caved in and started nitrox training; they were the last of the major agencies to do so. Bill Gleason was unceremoniously fired from Skindiver. Less than three years later Peter Bennett was ousted from his position at DAN after writing a completely inaccurate editorial about nitrox dangers. This time there was an industry backlash that forced an international conference on nitrox practice that totally repudiated every single thing Bennett, Skindiver, and the other nut-balls had very written on the subject. It was "bitch slap" to the extremists of phenomenal impact. A consensus standard for ntirox use was published in the Proceedings journal that followed. All the industry participants, medical experts, and featured faculty experts had unanimously agreed that nitrox was appropriate for recreational divers and affirmed the very procedures and protocols that we had been advocating since the early 1970s. In an even bigger slap to the ousted Bennett, DAN both sponsored the conference and published the Proceedings!

The entire era of extreme controversy barely last eight years. All of the naysayers were proven to either be totally uniformed on the subject intellectually or to have their own hidden personal agendas. All the bad guys were deposed and driven into exile. Nitrox, diving computers, and technical diving became mainstream and widely accepted everyday practice worldwide. And the new technology proved to be the widest profit-making segment of the diving industry in history.

What would you rather sell as a dive store owner? A $5 set of dive tables or a $1200 diving computer? You do the math...

Dick Bonin, founder of Scubapro, who led the development of the best diving equipment for deep open circuit use beginning in 1970 (photo from Bonin archives)

Even places like the Caymans ended up sealing their own fate as their absurd restrictions drove experienced divers elsewhere leaving them with mostly neophytes as a customer base. These customers did need a lot of supervision since they were barely out of dive class and wanted to be constantly supervised so someone could save them if faced with a crisis like having to clear their mask or some other monumental issue. Experienced resort staff opted to go elsewhere so they didn't have to constantly babysit the newbies and then the continued deterioration of the reefs and underwater environment drove the best spending active diver demographic off to the Indo-Pacific, Galapagos, Cocos Island, Micronesia, etc. With the Cayman's overly inflated prices as well, divers discovered they could see truly "world class" diving for about the same price... and no one acted like the "Scuba Police" when the wanted to dive solo, use nitrox and a computer, or dive deeper than 100 feet (30 meters). Even after they grudgingly accepted nitrox, dive computers, etc. the Caymans and other such areas have never recovered.

It was a stunning crash to inglorious defeat and banishment for the most extreme of the arch-conservatives. And frankly, I don't miss them.

As Dick Rutkowski famously said, "Science always triumphs over bullshit." He was right. But the battles made things interesting for awhile.

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The golden compartments: halftimes from a different perspective

By Asser Salama

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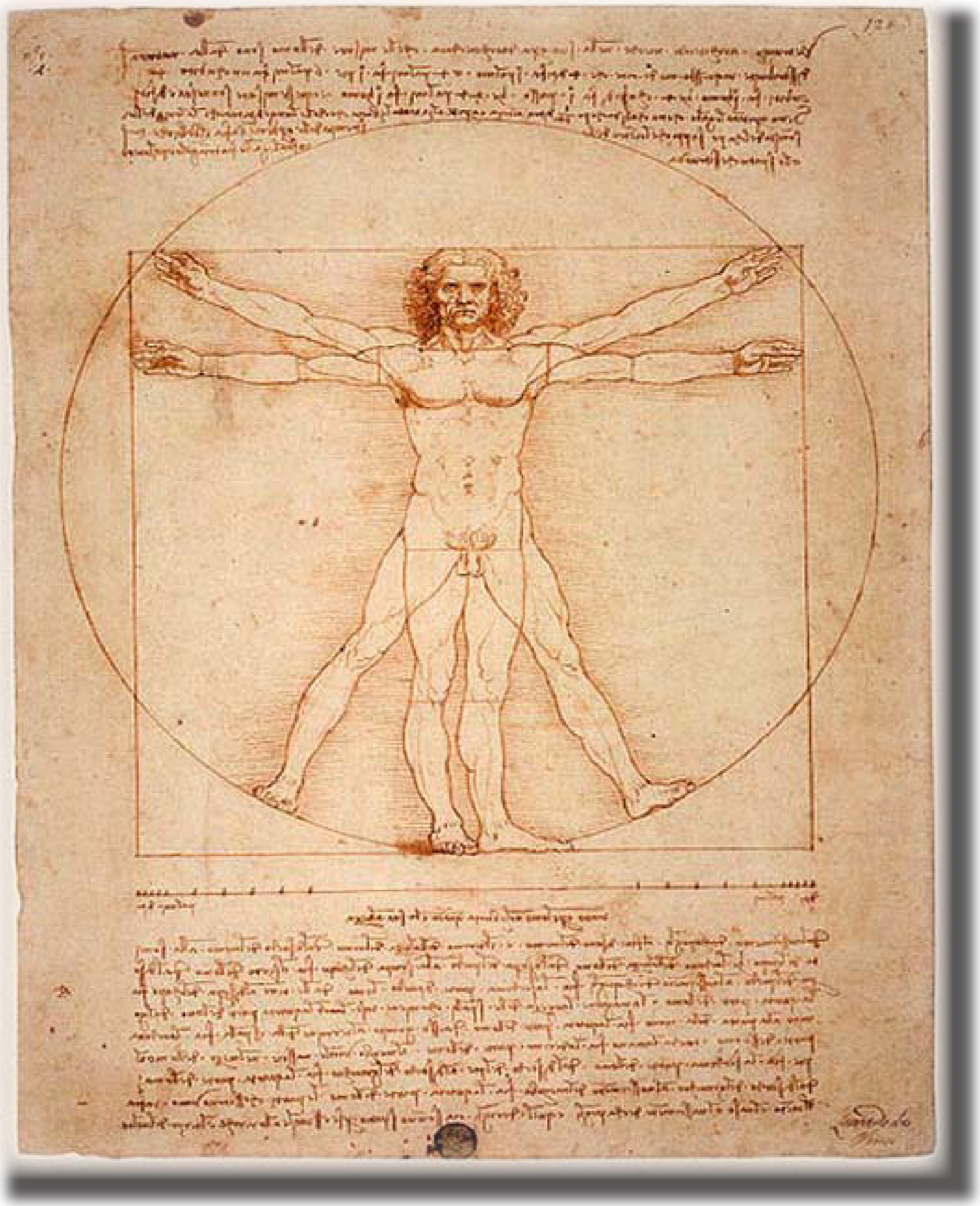
While reviewing some of Buhlmann's work, particularly the ZH-L12 versus the three variations of ZH-L16 model, I noticed that he has changed the halftimes, even though both sets are covering virtually the same range. The older ZH-L12 model's half times of nitrogen start at 2.65 minutes and end at 635 minutes, while those of the newer ZH-L16 model start at 4 (optionally 5) minutes and end at 635 minutes. Both models assume 16 tissue compartments. On reviewing other models such as the DCAP MM11F6, which is considered one of the most conservative models, I noticed that it covers a wider range of half times (5 to 670 minutes for nitrogen), although it assumes only 11 compartments.

While surfing the Internet, I frequently bump into opinions claiming that the more tissue compartments the better the model is. So how does the number of tissue compartments relate to "accuracy"? What difference does their distribution over a particular range make?

In order to answer these questions, it's necessary to come up with a brand new set of half times and incorporate it into VPM-B-based software. As you remember from the "Accelerating no-fly time using surface oxygen" article featured in the first issue of Tech Diving Mag, I already have a VPM-B-based piece of software (originally developed by Jurij Zelic). The original software is based on Eric Baker's original FORTRAN code. The program employs the sixteen paired compartments (total of 32 compartments; 16 for nitrogen and 16 for helium) of Buhlmann's ZH-L16B model. The optional compartment 1b is put into use. After implementing this new set of compartments, let's then compare the resulting profiles with the original ones.

I'm aware that the models mentioned above (ZH-L12, ZH-L16 and MM11F6) are pure dissolved gas models, while the VPM-B is a dual phase model. However, all we need to know is the effect of the number of compartments and their distribution, so M-values have no effect here.



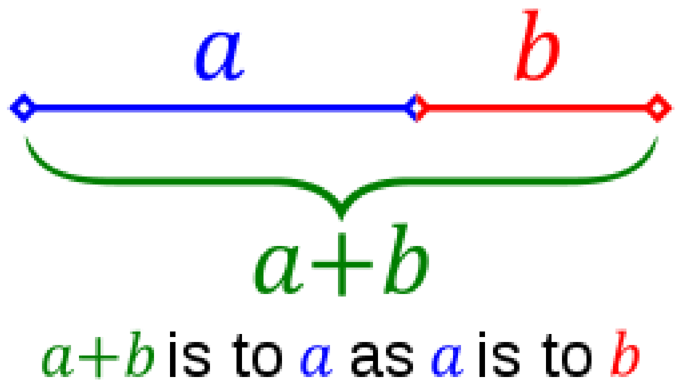
***Vitruvian Man* by Leonardo da Vinci**

The golden ratio

Two quantities are in the golden ratio if the ratio of the sum of the quantities to the larger quantity is equal to the ratio of the larger quantity to the smaller one. The golden ratio is approximately 1.6180339887. It has been used in aesthetics, architecture, painting, book design, perceptual studies, music, industrial design and nature. Some famous painters like Leonardo da Vinci suggested that some bodily proportions exhibit the golden ratio. Actually he illustrated this in his extremely famous drawing, the ***Vitruvian Man***, which is regarded as a cultural icon.

So now I think it's time to incorporate the golden ratio in scheduling decompression profiles! We will start the nitrogen half times at 4 minutes and multiply this number by the golden ratio then multiply the result by the golden ratio again and again, until we cover the entire range that Buhlmann's ZH-L16B model is covering. The result is as follows (rounded to two decimal points):

CPT #	N2 half time
1	4
2	4 x 1.6180339887 = 6.47
3	6.47 x 1.6180339887 = 10.47
4	10.47 x 1.6180339887 = 16.94
5	16.94 x 1.6180339887 = 27.42
6	27.42 x 1.6180339887 = 44.36
7	44.36 x 1.6180339887 = 71.78
8	71.78 x 1.6180339887 = 116.14
9	116.14 x 1.6180339887 = 187.91
10	187.91 x 1.6180339887 = 304.05
11	304.05 x 1.6180339887 = 491.97
12	491.97 x 1.6180339887 = 796.02



The helium half time is nothing more than dividing those of nitrogen by 2.6455, which is the diffusivity ratio of helium to nitrogen. This means that the helium compartment half times will still be in golden ratio. The comparison of our new set of compartment half times, which we'll call GR12, to that of Buhlmann's ZH-L16B is as follows:

CPT #	GR12 – N2	ZHL16 – N2	GR12 – He	ZHL16 – He
1	4	4	1.51	1.51
1b	N/A	5	N/A	1.88
2	6.47	8	2.44	3.02
3	10.47	12.5	3.96	4.72
4	16.94	18.5	6.4	6.99
5	27.42	27	10.36	10.21
6	44.36	38.3	16.77	14.48
7	71.78	54.3	27.13	20.53
8	116.14	77	43.9	29.11
9	187.91	109	71.03	41.2
10	304.05	146	114.93	55.19
11	491.97	187	185.96	70.69
12	796.02	239	300.9	90.34
13	N/A	305	N/A	115.29
14	N/A	390	N/A	147.42
15	N/A	498	N/A	188.24
16	N/A	635	N/A	240.03

The decompression profiles

I prepared for three dives, two of which are to 75 meters (246 feet) with different bottom and travel mixes, and the third is to 90 meters (295 feet). The decompression profiles were generated using the new toy, which I call VPM-B/GR12. The conservatism level was set to zero, which is what I normally use for my "recreational" (also known as "fun") dives. The reason is that I believe Eric Baker has done a brilliant job when he managed to fix the VPM bug by using a physics-based fact (Boyle's law), rather than just coming up with some mathematical correction factors. Now the conservatism VPM-B-based programs use assumes change in the molecule size of inert gases, which is not true! In conclusion, when I feel like adding more conservatism, I just adopt the very same zero conservatism profile and add more minutes (usually 3 to 5) to the last stop (usually at 6 meters – 20 feet using either 80 or 100 percent oxygen).

© Andy Connor.

The complete profile of the first dive is as follows, and a comparison to the segment time generated by GUE's Deco Planner for a similar dive is also enclosed and is marked (DP). The surface interval is one week, the descent rate is 20 m/min (66 ft/min) and the ascent rate is 9 m/min (30 ft/min).

Depth	Seg time	Run time	Mix	Seg time (DP)
60 m – 197 ft	0 min	3 min	Tx20/26	0 min
75 m – 246 ft	17 min	20 min	Tx16/45	17 min
48 m – 157 ft	1 min	24 min	Tx20/26	1 min
45 m – 148 ft	1 min	25 min	Tx20/26	1 min
42 m – 138 ft	1 min	26 min	Tx20/26	1 min
39 m – 128 ft	1 min	27 min	Tx20/26	1 min
36 m – 118 ft	1 min	28 min	Tx20/26	1 min
33 m – 108 ft	1 min	29 min	Tx20/26	1 min
30 m – 98 ft	1 min	30 min	Nx40	1 min
27 m – 89 ft	1 min	31 min	Nx40	1 min
24 m – 79 ft	1 min	32 min	Nx40	1 min
21 m – 69 ft	2 min	34 min	Nx40	2 min
18 m – 59 ft	3 min	37 min	Nx40	2 min
15 m – 49 ft	3 min	40 min	Nx40	4 min
12 m – 39 ft	4 min	44 min	Nx40	4 min
9 m – 30 ft	6 min	50 min	Nx80	6 min
6 m – 20 ft	21 min	71 min	Nx80	21 min

You will notice that the only differences between the VPM-B/GR12 profile and the one generated by Deco Planner is the stops at 18 and 15 meters (59 and 49 feet). The total run time is the same though. The same happens for the second and third dive, with the exception that for the third dive, the VPM-B/GR12 profile's total run time was one minute longer. The differences between the VPM-B/GR12 profiles and the ones generated by the very same piece of software (with the exception to employing Buhlmann's ZH-L16B compartment half times) were negligible.

The dives

My buddy was Aaron Bruce. Aaron is a TDI instructor trainer and advisory panel member. I was using open circuit while Aaron was using an electronic CCR; the APECS Megalodon with Shearwater redundant controller hardwired into the head with a standard can and a Golem Gear radial scrubber. We had Stefan Bol as a support diver. Like Aaron, Stefan was using an electronic Meg. To add more contrast to the picture, Aaron and Stefan were in their dry suits, while I was diving skin, without any thermal protection. This was in Sharm El Sheikh, Sinai, Red Sea, Egypt in December 2010. The water temperature was 25 degree Celsius (77 degree Fahrenheit).

Aaron was using an OSTC Mk.2 dive computer, which uses Buhlmann ZH-L16C algorithm in addition to gradient factors. He tends to use a gas mixture that gives him an END of 35 meters (115 feet) and a set point of 1.1 at the maximum depth. For our first two dives, the CCR set point was 1.4 and the computer's gradient factors were 45/90. According to his dive computer, Aaron's first decompression stop was at 27 meters (89 feet), but he was following my plan, meaning that he started stopping at 48 meters (157 feet). The end result was my very same profile. On the third dive, the one to 90 meters (295 feet), Aaron used 30/90 gradient factors rather than 45/90. He tried to follow my profile. It worked fine for the deeper stops, but starting at the 30 meter (98 foot) stop, his computer showed different stop times. His total run time was longer than mine by 4 minutes. The end result of following the VPM-B/GR12 profiles was that no one got bent.

Conclusion

The number of tissue compartments and their distribution over a particular range do not seem to make a tangible difference to the decompression profiles generated by VPM-B algorithm.

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Thanks to Anthony Pasquale for reviewing the grammar.

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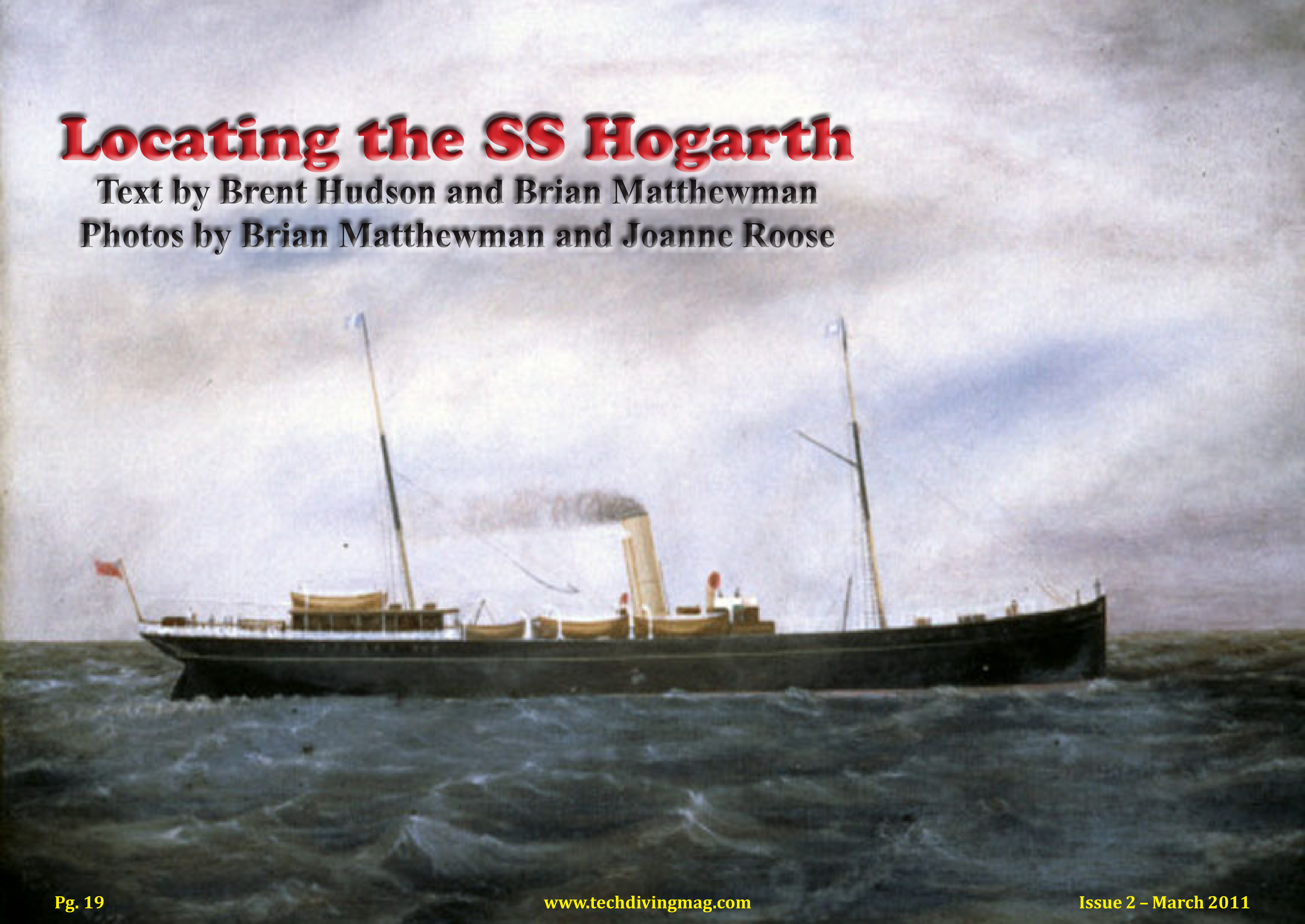
Locating the SS Hogarth

Text by Brent Hudson and Brian Matthewman
Photos by Brian Matthewman and Joanne Roose

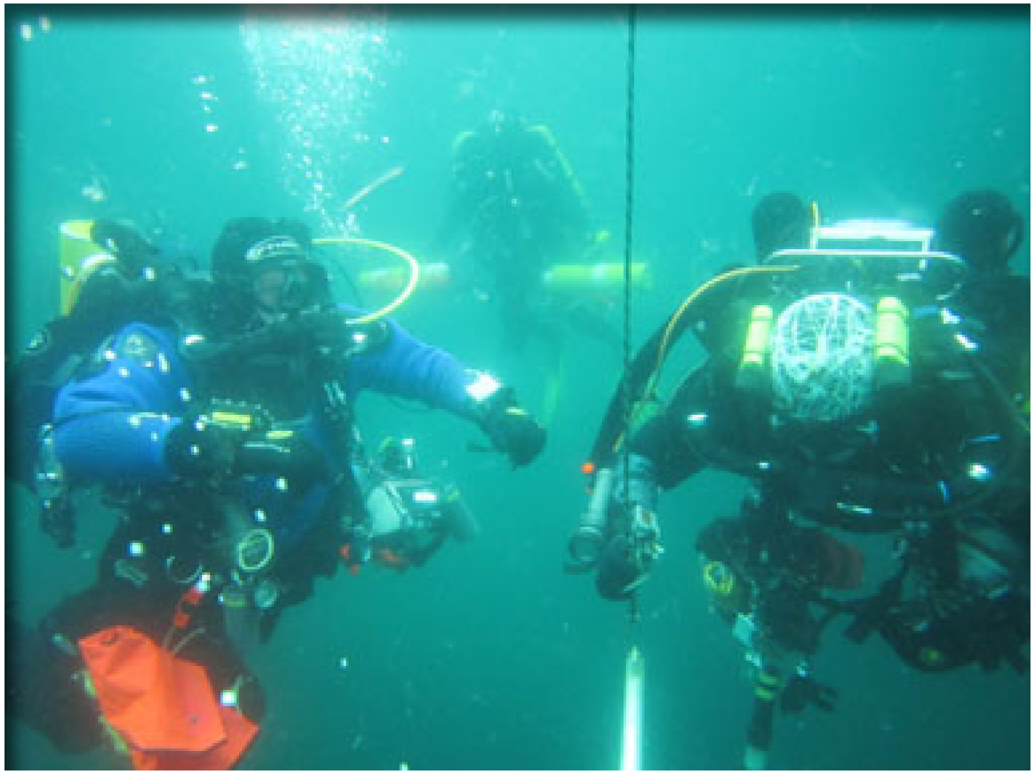


A team of technical divers has located and firmly identified a WWI cargo ship wreck with an illustrious past. The wreck was identified as that of the SS Hogarth, a merchantman torpedoed in the North Sea in June 1918 by a German U-boat. The ship's captain, Captain David Stephen, had two years previously taken heroic action upon the torpedoing of another British Indian Steam Navigation Co ship. He had laid the Hogarth alongside to take off crew from the sinking vessel, while the attacking U-boat remained in the area. For his action, Captain Stephen received a number of awards including the Lloyd's Silver Medal for bravery in saving life at sea. The medal was awarded to him in the very month in which he went to sea and was lost with the Hogarth, after it was sighted on a calm night by UB107. One of the ship's two gunners was the sole survivor out of 26 crew members.

The 60m-deep wreck, with intact hull but collapsed superstructure, was found by the Silent Running technical diving team led by Brian Matthewman. The eleven rebreather divers and a surface support diver operated from Alan Lopez's Tyne-based Spellbinder II, as part of a project to explore various marks of interest in the Tyne area. The SS Hogarth, however, was not a chance find but a fully expected one. The team had conducted some careful research over the winter period, with assistance from North East wrecks authority Ron Young, in their bid to locate the wreck which local divers had long wanted to find.

Officially, as listed in the Dictionary of Disasters at Sea 1824-1962, published by Naval and Military Press, the ship was lost in the vicinity of the Farnes Islands, some "ten miles south-east" of the Farnes' Longstone light. This record had guided many divers searching for the SS Hogarth. Although Silent Running Dive Team is located in the North East of the UK, Brian and Brent travelled to Liverpool to hit the books. Enquiries at the Liverpool Maritime Museum, which holds other wartime sinking records complete with U-boat references, yielded a transcript of the log entry completed by the captain of UB107 which sank the SS Hogarth. This described an area of action further south and not far offshore, with reference to being able to see town lights on the mainland. Also unearthed was a letter from a manager of the Hogarth's shipping line, stating that he had been told by the surviving gunner that the ship would have been, in the gunner's estimation, "just north of the Tyne" and "about 30 miles south of the Farnes" when sunk. This tallied with the U-boat's account. The Silent Running team "had something to get our teeth into", said team member Brent Hudson. And amazingly, while "unknown marks in the Tyne area are numerous", the divers were fortunate enough to hit the bull's eye with the very first mark which they elected to dive once they arrived in the area in which they reckoned the SS Hogarth should have gone down.

"Visibility was very poor near the surface, but at depth it was about 10m", said Hudson. "Although there was little penetrating light, the dive was exceptional." The divers descended to find an intact hull, though with collapsed superstructure, sitting upright on a bottom of gravel and shale. The wreck was remarkably clear of fouled netting, often a serious wreck-diving hazard to us in the North Sea. Two boilers, consistent with the Hogarth's design, and a cargo which appeared to consist of the ship's regular manifest of building materials, could be seen.



"The excitement was building as the pieces started to fit, but disappointment is never far away", said Hudson. The team needn't have worried. Settling near the centre of the wreck, wooden decking and "other objects indicative of the superstructure" were apparent. But a "bit of rummaging" soon yielded pieces which would identify the wreck beyond doubt. Clearly working amongst remains of the bridge, Matthewman found the ship's helm. This gave them an area to concentrate on to find real evidence of the ships identity. The identities of artifacts aren't immediately apparent, and sometimes a bit of rummaging is required. Hudson spotted an unusual shape in the silt that had settled over the years on the superstructure. Reaching into the hole and feeling around with his 7mm mitts, a small portion of a curved edge found his grip. It was heavy and started to move causing a large amount of silt to instantly remove all visibility. This is where teamwork is critical, and also where the dive team excels. Matthewman is immediately alongside Hudson and between them the object is carefully brought into the clear water. They found the bell, a big one too and in excellent condition. Followed shortly by the helm, the objects are sent to the surface with multiple lifting bags.

The divers ascended having enjoyed an hour on the wreck, with decompression at their suspended deco station giving a total dive time of two and a half hours. The long decompression is necessary due to the substantial percentage of helium the divers require for these depths.

Hudson stressed just how satisfied the team had been to be able to identify the Hogarth and raise items which would help remind people about the ship and her exploits. "The regional link to Captain Stephen is special, his medals and some pictures of himself and his ship all residing at Aberdeen Maritime Museum", said Hudson. "Our finds have been declared to the Receiver of Wreck and, for now, remain in our care at Narked at 90. We have been advised that the items will granted to us in lieu of salvage, as the company which owned the Hogarth went out of business in 1962, however due to the workload of the Receiver of Wreck we are overdue in receiving our droit." In the mean time, the artifacts have been proudly on display at the Aberdeen Maritime Museum and will be made available to the Museum anytime they request them.

"It is important that the social history of these great stories is remembered" Said Matthewman. "An essential part of our responsibilities as technical wreck divers is to liaise with any institution where display would help preserve the memory of these historic wrecks and individuals like Captain Stephen and his fellow lost crew."

Meredith Greiling, Assistant Keeper of Maritime History at Aberdeen Maritime Museum, has several medals awarded to Captain Stephen, along with photographs of the ship and her illustrious captain. "The SS Hogarth material was on display in an exhibition at Aberdeen Maritime Museum about the shipbuilders Hall Russell & Co (who built the Hogarth)."

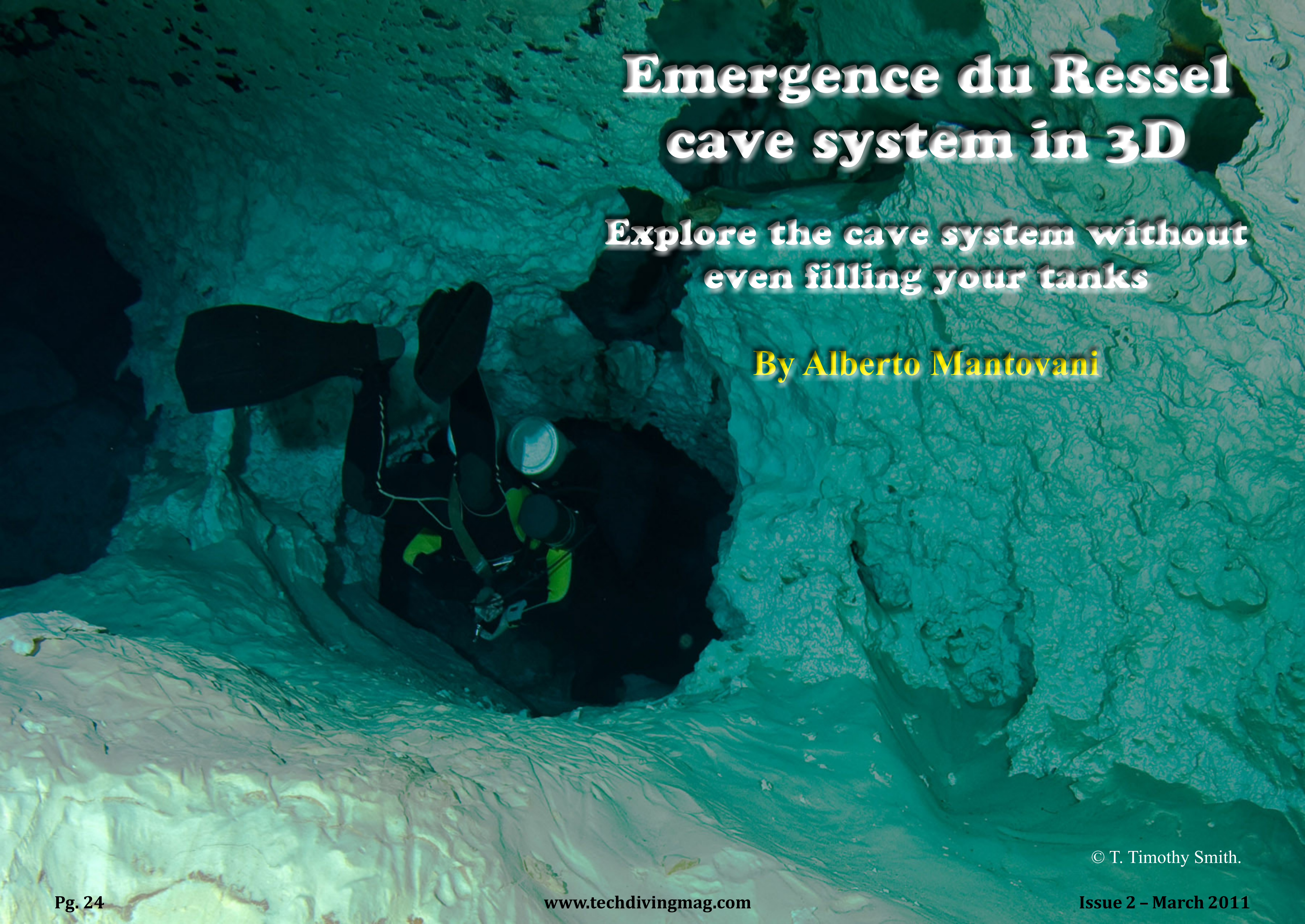
The Hogarth diving team was: Brian Matthewman "Expedition leader", Brent Hudson, Joanne Jefferson, Steve Richardson, Mark Blewitt, Mark Parry, Steve Anderson, Bob Karman, Andrew Dewhurst, Dave Close, Ian Davidson and Chris Roose. The team's rebreathers were a prototype worn by Brent Hudson, of manufacturer Narked at 90; Camillion Gen 4, six Inspiration Visions, of which three carried Narked at 90 back-up electronics; two Inspiration Classics; and a Shearwater Classic KISS.


SILENT RUNNING
MIXED GAS DIVE TEAM

Emergence du Ressel cave system in 3D

Explore the cave system without even filling your tanks

By Alberto Mantovani

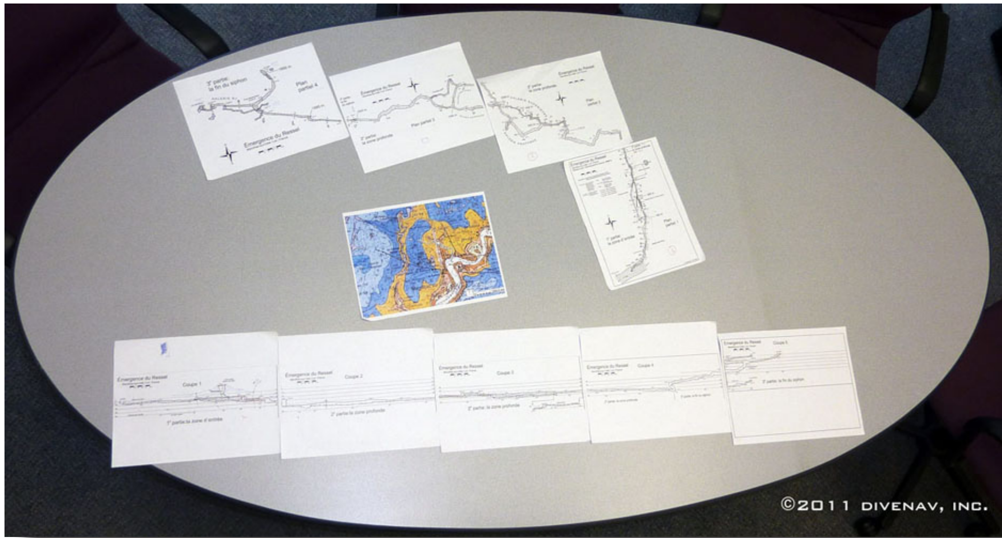


© T. Timothy Smith.

If you've never heard of eDiving; it's a unique experience. eDiving was born from a desire to offer divers the ability to explore and familiarize themselves with a dive site before getting wet. It has since expanded to include not only exploration but also training and gaming. Though we at DiveNav, didn't originally design eDiving with tech diving in mind, it couldn't be more useful than in the world of tech diving.

The eDiving simulator is a computer-based tool that allows you to explore real dive sites around the world. Each site is created with painstaking detail using an excess of images, and either high-resolution bathymetry for natural reefs or deck plans for artificial reefs. Once the site is created, the almost 15,000 (and growing) eDivers from around the world can explore and prepare for their next dive. The simulator takes into account your nitrogen and helium loadings using the Buhlmann ZHL-16C algorithm, oxygen exposure, buoyancy, stamina, fins efficiency, breathing rate, body type, wetsuit compression, thermal characteristics, and much more. Though, unlike real life, you can restart your dive if you run out of air.

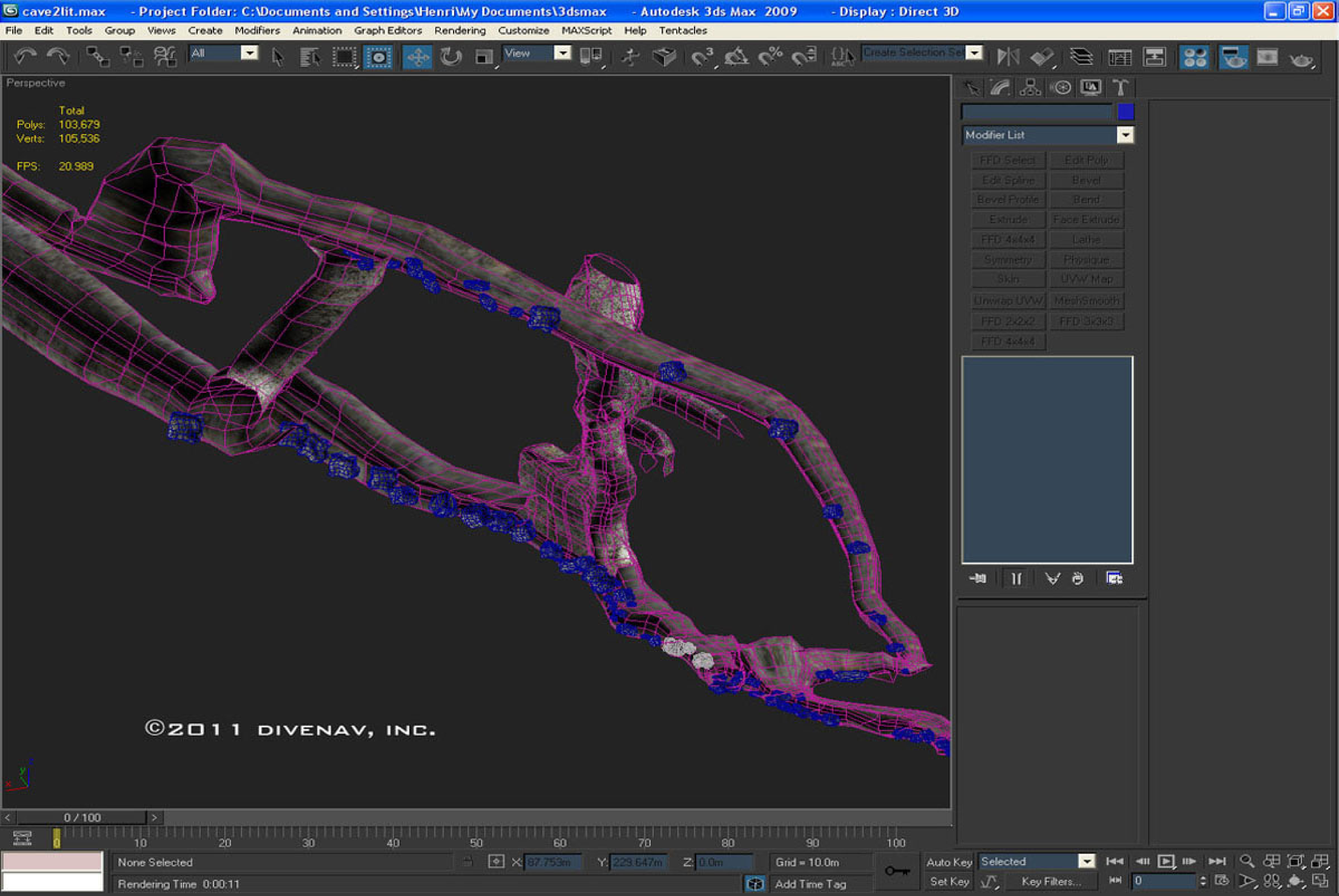
For some time, the eDiving team had the desire to create a virtual dive site of a real cave. The problem: how do you get the data to accurately map the inside of a cave? There is limited mapping data on caves let alone data detailed enough to create a virtual dive site for it. In our search for data, we contacted several experts in the field that claimed to have extensive data, but unfortunately, as of today we have not received any. In the meantime, one of our members recommended that the first cave site be the Ressel cave system in France and directed us to the website of Markus A. Schafheutle. His website had detailed data including a birds-eye view, cut-away views, cross sectional map, and depth-profile for the entire cave system (figure 1). Unfortunately, the accompanying explanations are all in French … and it took some work for us to understand the data. We then geo-referenced that data with Google Maps and slowly built a virtual Ressel cave system. Once the first section of the cave system was completed we then developed the virtual world around it.



The creation of the cave system was a new and exciting challenge for our design team. The most difficult part was the interpretation of the elevation view deviations and the overall geometry of aligning the various levels of the Ressel cave system. After reviewing all the raw data, the project began by importing all the images into AutoCad (of Autodesk) and properly scaling them. We then traced the outlines of the various tunnels and noted the locations of the larger rock pile locations. The next step was to export everything into 3D Studio Max (of Autodesk) and begin the detailed process of creating the models. Here we blended the shapes of each section together and formed the rocky sections. To make the rocks look like rocks and cave walls look like cave walls, you need to add a texture to each model. Our design team referenced photos and video that had been gathered from dives on the real Ressel cave system and created numerous textures using Adobe Photoshop. Once the challenging job of creating textures that appropriately reflect each section of the cave was complete, they were applied to the models in 3D Studio Max. The cave system is almost complete. However, there are still numerous steps to make it usable in the eDiving Simulator. The cave system must be divided in sections to allow the addition of collision models, ensure the orientation of each model is correct, then using detailed naming conventions each model is exported from 3D Studio Max to a .x file using the Polytrans plug-in developed by Okino. We then take the .x file of each model and using our proprietary software, convert and encrypt it into our proprietary format used by the simulator. Using another proprietary tool, we then convert the scene generated in 3D Studio Max into a proprietary scene file format that could be read by the simulator. Once the scene is completed, we test it locally by virtually diving it on our local server and once all the tests are complete, we "publish" the new site on the public server so any member of the eDiving community can enjoy it.

The virtual cave seen with 3D Studio Max looks like a series of simple tubes in black space (figure 2). In order for us to create a complete site, we needed to populate the environment around the cave system using state of the art 3D design software to resemble the terrain at the real cave in France. Though the site is still in progress, over 1,000 meters of the entire 1,850 meter cave system has been created and is available for exploration.

The process of creating the first 1,000 meter section of the Ressel cave system took our team almost 200 hours of work. Though the texturing and blending of shapes was the most time consuming process, aligning the elevation profiles of the cave system was certainly the most challenging. In comparison to our previous experience creating artificial reefs for the eDiving simulator, the Ressel cave system presented its own challenges. The access to detailed data, however, allowed for a much clearer image of its structure. Typically deck plans for an artificial reef are incomplete or are plans before the ship had been modified leaving holes in the data required for its creation. After putting so many working hours into the Ressel project, we were eager to take the first virtual dive in the Ressel cave system in the eDiving simulator. Despite having a good perspective of the caves from viewing it in 3D Studio Max, however when diving it with the simulator the perspective becomes "an experience". Being "immersed" in the Ressel cave with the simulator is very different than seeing the structure of the cave system with 3D Studio Max. In our opinion, so far, one of the most interesting parts of the Ressel cave is the "puits-cloche" (bell-shaped well) at about 250 meters. This area has a series of interconnecting tunnels with one of them ending in a bell shaped room, in which you can ascend to the surface and see the sky high up above you. (See figure 3 for a rendering of this area in 3D Studio Max and figure 4 for a view of the room from the simulator).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the simulator a fully functional rebreather. Also, since the cave system is getting longer and longer, we recently added scooters and are currently designing into the simulator the ability to use more than three tanks and drop (and retrieve) stage bottles in the virtual scene. Until then, a scooter and rebreather will be your best bet to come back alive. (See figure 5 for a technical diver equipped with rebreather and scooter).

The Ressel cave system is only the first of many caves we would like to create for the eDiving simulator. Though the simulator has received mixed responses from the tech diving community, creating the next cave site will depend on them. Many tech divers get the impression we are attempting to replace virtual diving with real dive training and experience. That is not the case. We intend for eDiving to be a supplemental tool for exploring real dive sites and frequently state that it is not a replacement for real diving experience. With that said, if you have never dove the Ressel cave system and plan to, would you feel a little more comfortable if you were familiar with its structure before taking the plunge?

Once a significant portion of the cave system was completed, a new challenge came about. We needed better dive gear to allow us to dive this cave system as one single aluminum 80 tank was just not enough. For our open circuit virtual divers we first added twin tanks, then we added stage bottles and, to allow them to explore the deeper part of the cave, we added support for Trimix. But we could not ignore our members that prefer to dive in closed circuit, so we added to

Without the cave diving community's assistance in gathering data, it will be extremely difficult to develop more virtual caves. If you have a recommendation for a cave site and have access to its mapping-related data, please log on to the eDiving forum at www.ediving.us and let us know about it. For now, enjoy virtual diving the Emergence du Ressel cave system in France from the comfort of your home.


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Sidemount diving: sport or tech diving, caves or openwater, novice or expert?

By Steve Lewis

© Ben Martinez.

Let's start at the very beginning. Sidemount diving has pretty quickly become one of the hottest trends and most discussed topics in recreational diving since the introduction of the Personal Dive Computer, but a lot of divers are asking themselves what exactly is it and what's it designed for? Well, perhaps we can outline the basic components of an open-circuit sidemount configuration; discuss its application; and give you a brief look at the pros and cons of sidemount diving for sport divers and techies.

The basic definition…

In sidemount diving the primary cylinders (the one or two scuba tanks holding whatever gases are going to be breathed on the bottom) are worn at diver's side. If you are familiar with the traditional North Florida Cave Diver's Rig consisting of a set of doubles with a manifold, a backplate and wing, the typical sidemount configuration has one clear and distinct advantage: the diver's back is left clear of potential entanglement hazards. There is nothing behind the diver's head to get into a complex argument with hanging wires, rocks, rotten wood, old light fixtures, coral or anything else.

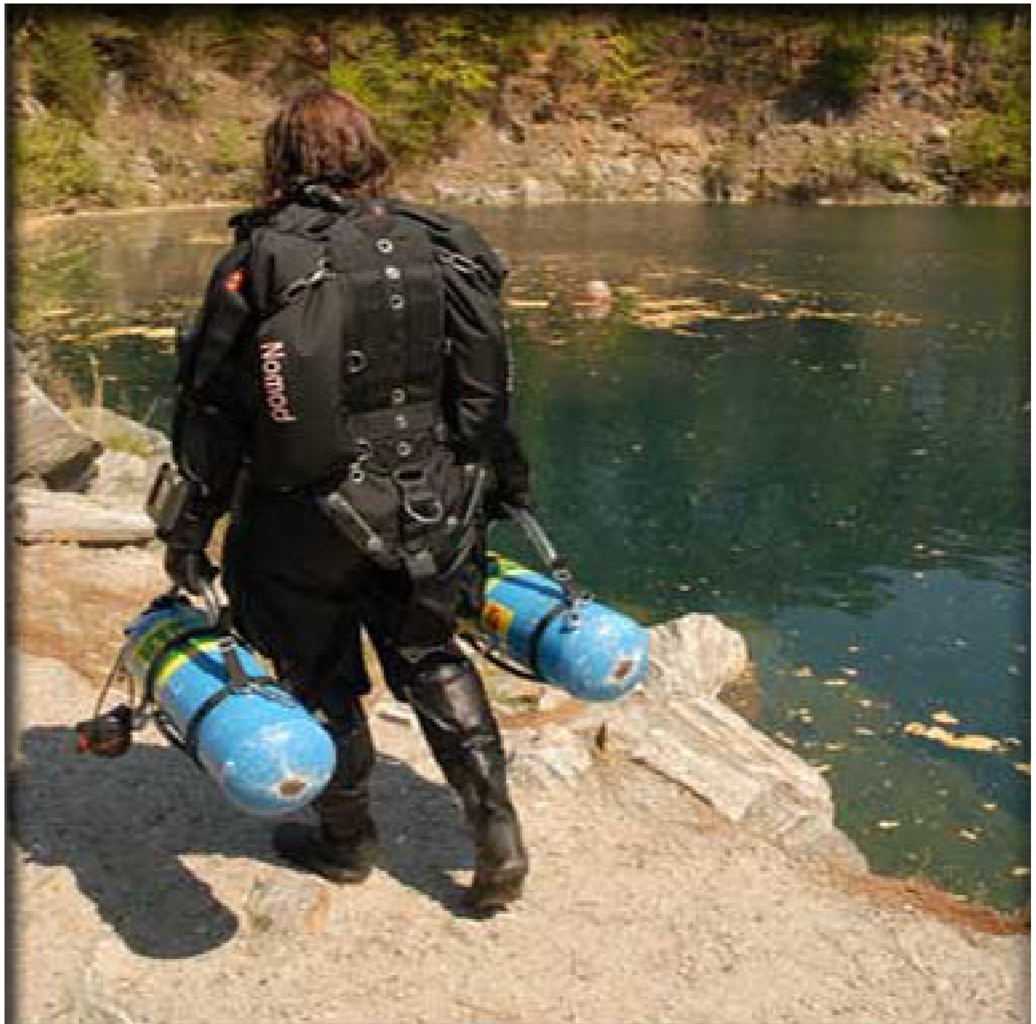
In its long-standing and original form, sidemount used two cylinders that were specifically independent singles each with a first stage, a second stage, an SPG and usually a low-pressure inflation hose (this translated into one to work the wing and another to inflate the diver's dry suit). This results in a kit configuration that is flat, low profile, streamlined, and axially stable.

Just to cover all the bases, sidemount today also has some non-Traditional definitions which include:

- Single cylinder sport diving
- Carrying bailout gas for Closed-Circuit Rebreather (CCR) diving
- Full sidemount Closed-Circuit Rebreather

Sidemount applications…

Convention has it that dry cavers working in the Mendip Hills of England were the first cave divers. They wanted to push their explorations beyond the pools of water that blocked their way and sump diving was the result. More specifically, sidemount sump diving was the result.



DiveRite Nomad harness. Photo Pete Nawrocky

History also credits the cave diving community of North Florida with the invention of a slightly different variety of sidemount diving. They too used it to navigate small passages with limited space between a silt-covered floor and a hard ceiling, and also to get through tight, high-flow restrictions to gain access to areas where conventional scuba kit was too ungainly or too logistically challenging.

Sidemount CCR diver... Photo Tamara Thomsen

At some point in the more recent past, the hard-line attitude that one and only one kit or gear configuration is correct gave way to the more inclusive practice of using tools suited to the job at hand. Sidemount became just another way to dive: when and where is up to the diver. It works in a sump, but it works equally well on an openwater wreck dive.

Lifestyle or mission specific…

Sidemount guru Lamar Hires of DiveRite explained that there are two major reasons to adopt sidemount as the kit configuration of choice: because you want to or because conditions dictate you have to. He labeled these two options, lifestyle or mission specific decisions.

Adopting sidemount for lifestyle reasons seems to be the main force that is driving the popularity of sidemount today. When you hear a diver say: "I am getting too old to carry doubles…"; "Sidemount looks and feels cool…"; "Getting back on the boat is easier…"; "It feels more stable riding a scooter…"; "Valve management is way easier…" or "I thrive off new challenges…" you are listening to lifestyle choices.

Mission specific reasons revolve around sidemount's characteristics of presenting a streamlined profile and offering less potential for entanglement behind the diver's head. This last benefit is a huge help on wreck penetration dives because there is virtually nothing on a diver's back to hold hands with hanging wires and cables, rotting wood and rusting steel. In addition, sidemount can grant access to areas of familiar wrecks that back-mounted doubles simply cannot squeeze through.

Expedition diving is another mission specific application for sidemount. The logistics of transporting, carrying and refilling cylinders in the field are easier with "singles" rather than sets of doubles. This is particularly true when a dive team is working with limited space and rough working conditions in which manifolds can be more easily damaged than a plain DIN valve. And divers who travel and who need the redundancy and gas volume available with two tanks rather than one, can carry a set of cam bands and a few pieces of hardware with them and convert readily available single tanks to primary sidemount cylinders in five or ten minutes.

Carrying decompression or stage gas. Notice the postition of the second (blue) tank and the anchor point for the rear clip

Mainstream equipment manufacturers such as Hollis, Oxycheq and DiveRite make functional, rugged sidemount harnesses in a variety of sizes and styles. Fit is hugely important and DiveRite has focused its efforts on making their Nomad unit as adjustable as possible to help ensure as near a perfect fit as possible. The rest of the kit consists of:

- Two regulators
- First/second stage, SPG, LP hose
- Balanced cylinders
- Size of bottle less critical than with backmount doubles
- Position of rear anchor point is critical
- Bottles can be adjusted quickly (even in-water)
- Long hose (x2 in some cases)
- Extra LP inflator
- SPGs (x2) on short hose
- Assorted hardware and accessories
- Bungees, cam straps, clips and small trim weights

The basic components…

The most critical single component is a one-piece sidemount harness. Gone are the days when sidemount divers cobbled together their own harnesses out of stab-jacket style BCDs and bicycle inner tubes.

Starting points…

If sidemount interests you, I'd suggest strongly that you invest the time in a SM workshop or entry-level course. SDI (Scuba Diving International the sport diving arm of TDI) offers a sidemount specialty. And as you might guess, any TDI course is available as SM course including: Intro-to-Tech; Decompression Procedures; Trimix; Advanced Wreck; and of course Cave.

Photo compliments of Pete Nawrocky, DiveRite

One good reason to attend a SM workshop is to work with an instructor to arrive at a good fit for the gear. DiveRite works with SM instructors from several major agencies certifying them Nomad Sidemount Instructors to help make sure that divers buying their kit get measured and kitted out correctly.

Most importantly, as with any new piece of gear, a diver needs to gain experience with sidemount before approaching the limits of his existing dive kit configuration. He should dive within NDL, dive shallow, and MANAGE HIS GAS CONSERVATIVELY.

If you do opt to take on the challenge of sidemount diving, practice in calm water or go shore diving. And remember that gas consumption must be closely monitored. The rule of thirds paramount; consume a fraction of available gas volume (pressure) from one cylinder then switch to other side, WRITE SWITCH PRESSURES ON A SLATE and follow them; and call your dive if in ANY doubt

All this said, it is important to remember that no single kit configuration is right for ALL applications. Sidemount is not the silver bullet and is certainly not the best option always and everywhere. However, a growing number of tech and sport divers are finding SM an interesting and enjoyable way to dive in many different environments. A good workshop is a great way to learn the technique and to find out the best ways to route hoses, hang lights, and configure deco bottles, but having a very flexible alternative to the traditional tech diver's kit for many divers is worth the extra effort.

Steve Lewis
TDI Instructor Trainer
doppler@techdivertraining.org

SS Dago

Text by Jorge Russo

Photos by Armando Ribeiro, Jorge Russo and Manuel Leotte

© Manuel Leotte.

The ship

SS Dago was a tramp-ship built in Dundee, Scotland, in 1902 by Caledon Shipbuilding & Engineering, Co. Ltd., as requested by Wilson Line of Hull. Wilson Line was purchased by Ellerman Lines and become Ellerman Wilson Lines. At that time it was the biggest privet merchant company in the world. The prefix "SS" commonly means "Single Screw", although some authors say it stands for "Steam Ship". The Dago was registered in the port of Hull that same year on behalf of Wilson, Sons & Co., Ltd. Her register number was 113645. She was 280 foot (85 meter) long and 1,653 gross ton volume. In 1909 she has been lengthened to accommodate 1,757 gross tons. In 1930, she has undergone a major repair.

With a steel hull, she had 5 hatchways and a single deck. In the engine room there were two steel boilers with 200 pounds of working pressure, powering a steam vertical reciprocating compound triple expansion engine, with 154 nominal horse power. SS Dago had a maximum speed of about 11.5 knots.

In 1902 the steam technology present in the SS Dago was, still, a modern one. But when she sank, this technology was already obsolete, as diesel engines had already started to take over. By the early 1940s, diesel engines were very common and largely used on merchant shipping, even in small tramp-ships like the SS Dago. Nevertheless, the ship was largely used for the war effort. Between 1939 and 1942, she was mainly transporting goods from and to England, especially in convoys OG and HO on the Gibraltar-Liverpool-Gibraltar Atlantic route.

The sinking

On March 15th 1942, the SS Dago was on a solitary voyage with no escort. She departed from Gibraltar heading to Liverpool. It was planned to stop in the Portuguese ports of Lisbon and Leixões, near Oporto. She was carrying 300 tons of general cargo. She had a crew of 37 men, 5 of them were navy gunners from the Royal Navy. Like many merchant ships in the WWII, the SS Dago was fitted with anti-aircraft defensive armament, including 2 Twin Marlins; 2 Hotchkiss; 1 stripped Lewis, 1 Holman Projector and 2 P.A.C Rockets, in addition to an anti-magnetic mine apparatus, switched off at the time.

It was a hazy afternoon with strong wind and swell. By 17:00H an aircraft was sited, and the crew was called to battle stations. Shots were fired toward the plane causing it to sheer away. Fortunately all missed; it was said to be a British Short Sunderland flying boat, but we believe that it was in fact an Australian one, from the RAAF, 10th Squadron, stationed in Mount Batten, near Plymouth in southern England or in Gibraltar.


© Jorge Russo.

SS Dago was steaming at 10.5 knots steering 010º from Lisbon to Leixões. At 17:35H she altered course to 352º in order to pass Cape Carvoeiro – Peniche, which is a small fishermen's town north of Lisbon. Around 18:00H another plane was sighted, this time no doubt: it was a German Focke-Wulf 200 Condor, which is a four-engine plane that entered service as an airliner for Lufthansa. Later versions for the Luftwaffe were used as long-range reconnaissance and anti-shipping bomber aircraft as well as transport planes for troops and VIPs like Hitler and Himmler. The plane approached from the bow, starboard side and on sight of the ship turned sharply and crossed her from bow to stern. At this time, no shots were fired from the plane. The ship's gunners were ready and everything was fired. The P.A.C Rockets were fired too soon and did not harm the Focke-Wulf. The plane managed to pass over the ship for two runs without being harmed, but on the third run the cannon was fired, not injuring any of the crew. Afterwards, a pack of three bombs was dropped. One hit the forecastle destroying it completely, the second fell in the second hold that was empty, and the third was a near miss, but managed to damage the bridge of the port side, destroying the deck emergency gear that stops the engine.

With only one watertight door, open at the time and the ship still running, the water from the bow probably got quickly to the engine room and the ship started to settle from the bow immediately after the bomb attack. The captain said that the water reached amidships when he came down off the bridge. The abandon ship order was given and the crew started to lower the boats. The chief engineer went down to the engine room and stopped the engine.

With the ship sinking rapidly and the stern so high from the water that they could see the propeller, managing the life boats was very difficult. One of them was almost lost by the propeller blades when the ship suddenly came down again. Fortunately the engine was stopped.

The crew testimonies state that the SS Dago sunk completely after only 5 minutes from the bomb explosions. Incredibly, from the 37 men no one got killed from the attack; only 4 injured, none seriously. One hour later, a motor life boat from the near fishing town of Peniche came and rescued them. Their life boats were towed to port.

This way the British 1,757 ton tramp-ship was lost with all her cargo, fortunately with no losses of life. She rests now quietly at approximately 50 meter (165 foot) depth.

The wreck
On a sandy bottom, 50 meter (165 foot) deep, just 500 meters (1,650 feet) from another wreck, there's what's left of the SS Dago.

The wreck is broken in two large segments, separated apart exactly in the second hold, where the second bomb exploded. The bow section lies on its port side, oblique to the stern section. The stern section lies straight in the bottom with the keel buried in the sand. The Bridge, galley and saloon were long gone and transformed in a sea of rubble, where we can see the very impressive triple expansion steam engine and boilers, standing out. In the forward hold, in the bow section, some of the cargo is still visible, such as a dozen of linoleum rolls with several different patterns.

In spite of the general destruction and deterioration, the wreck with its two segments is a very impressive view. Normally the open sea dive on the SS Dago means rough swell, strong currents and poor visibility, at least till 25 to 30 meters (82 to 98 feet), but after that, usually, the sea seems to open for the divers and the SS Dago wreck shows with all her splendour.

Being at 4 kilometres (2.5 miles) from the shore and 50 meter (165 foot) deep, it is not an easy dive. We can only dive there in very good weather conditions and, of course, with the adequate certification, experience, gear, training and surface support.

It is certainly one of the best dive experiences of its kind in Portugal and a time capsule, that we deeply wish and ask to be preserved, in an attitude of respect for the wreck, who built the ship, who crew her and who survived that March 15th 1942. Finally, respect for all the divers to come, who certainly prefer to observe it complete with all its detail and not dilapidated in a form of worthless souvenirs.

The research

It has long been heard about the location of the Dago. The fishermen spoke often of a location where they lose the fishing nets, as the presumed site of the sinking. Many divers "went to Dago", but in reality, no one had gathered the evidence necessary and sufficient.

This uncertainty was reinforced by the existence of another wreck a few 500 meters (1,650 feet) away. When we asked the fishermen, divers and diving centers, where the Dago is, sometimes they indicated the coordinates of one, sometimes of the other. The testimonies were distinguished when describing the Dago; sometimes it was one wreck, others the other one. It was necessary to undertake a more rigorous and scientific gathering evidence on the ground, and simultaneously enhance the historiographical research around the ship, its owners, its technology and the aircrafts responsible for her sinking.

Naturally it is impossible and irrelevant to determine who the first to dive the wreck was. We know that the group *In Silence* made some dives in 2005. *XploraSub* started diving there in 2007. On the same occasion also Paulo Costa was interested. Team member and author of the first national magazine article about the sinking, probably was the first person who became interested in her historiography. Paulo Costa gathered the largest and most important set of documents known about the ship and the sinking.

In 2007, João Sá Pinto directed a documentary for RTP2 Portuguese national television. In this documentary we watch the historiographical issues surrounding the ship and the sinking, and the wreck is observed through an amazing set of images, captured between 2005 and 2006.

In August 2007, a happy coincidence has created conditions for the initiation of a genuine research project around the SS Dago. The author was looking for a team with training, experience and interest to investigate this wreck, and XploraSub was seeking scientific guidance for the same purpose. With the synergies of this collaboration and integration of Paulo Costa, a diver himself, the project started. The project had two main objectives: The historiographic research and in situ records of the wreck, which would run simultaneously.

The dives were initiated immediately with the aim of mapping the wreck first, measuring it, checking its orientation and context, and most importantly, taking measures to collect outstanding areas of the ship for comparison with plans at the time of its construction. We wanted to prove which of those two wrecks actually corresponds to SS Dago, if any. For this purpose we analyzed the two wrecks, not just what was usually referred to "Dago".

Luck was on our side and the second wreck had an engine, that even though a steam engine, does not coincide with the SS Dago's one. The second wreck was then deleted from the possibility notes. Now we had to find remarkable structural correspondences between the ship's plan and the wreck.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Based on the first dive, the remarkable data collected, and after holding a comparison with the plans of construction, we can now reliably say that, in fact, the place where the fishermen know there is an artificial obstacle that divers considered as "the Dago", was indeed the wreck of the SS Dago, which was lost in Peniche, Portugal in 1942.

At present, the investigation continues, the wreck continues to be recorded and every day we receive new info and documents related to the ship and her sinking.

The team

XploraSub is a group of Tech divers that exists since July 6th, 2005. The team's aim is to explore and hold researches in areas accessible only to advanced divers. Our main areas of interest are wreck and cave diving. Presently we are developing several projects on both areas.

We recognize that the development of projects within this framework is only possible through a cohesive team, continuous updating of knowledge, access to specialized equipment and sharing information and experience.

The SS Dago project team is Carlos Gomes, Carlos Trindade, João Pedro Freire, Jorge Russo, Luísa Tavares, Manuel Leotte, Nuno Sousa, Paulo Carmo, Paulo Correia, Paulo Costa, Pedro Encarnação, Pedro Ivo, along with invited photographer Armando Ribeiro.

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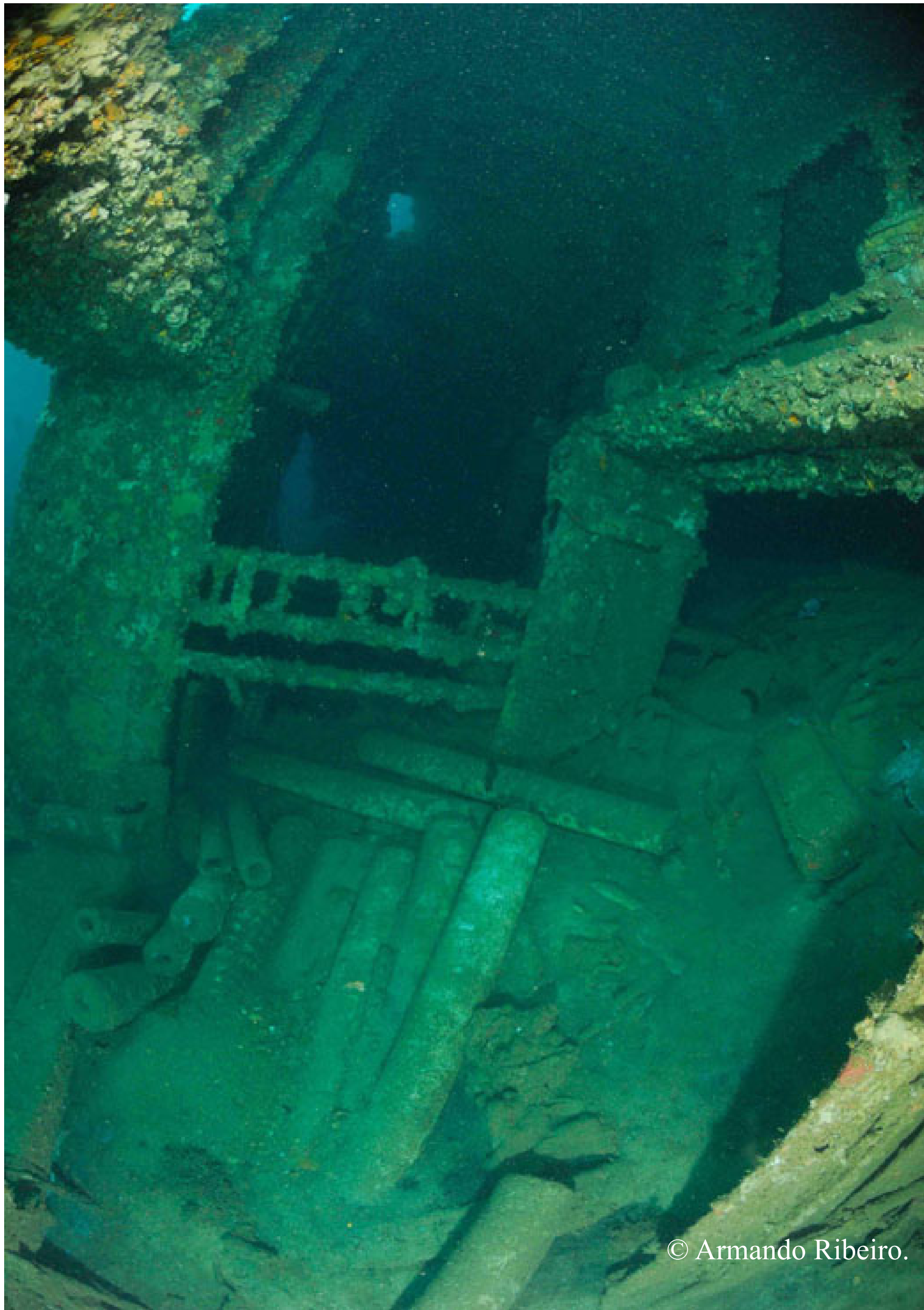


A practical discussion of nitrogen narcosis

By Bret Gilliam

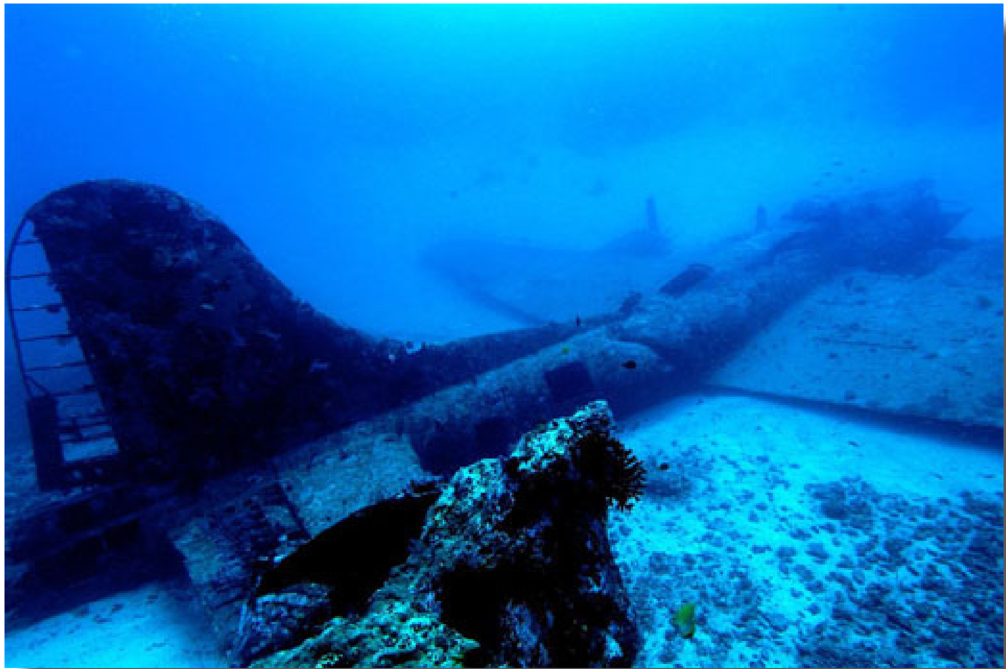
A HISTORICAL PERSPECTIVE

There have been numerous articles written on the subjects of inert gas narcosis and attendant depth limitations. Many have re-hashed old formulas relating the preposterous "Martini's Law" etc. and sanctimonious admonitions against any sport diving below 130 fsw (39.4 m). The authors of these materials are motivated by the best of intentions: diving safety. The problem lays in the fact that sport divers *are* diving deeper than 130 fsw (39.4 m) *routinely* and in ever-greater numbers each year. It is important for those of us professionally involved in the sport to accept the reality of such diving practices and disseminate accurate information that adequately conveys the relative hazards and operational disciplines necessary to undertake deeper diving within the proper boundaries of responsible physiological planning and reasonable assumptions of risk. It is not sufficient to adopt of attitudes of condemnation when what is clearly called for is an enlightened attempt at proper education.

It's worth noting here that technical, cave, rebreather, and other types of exploration diving all fall, by legal definition, into the "recreational" category of diving within the U.S. This is because the Occupational Safety and Health Administration (OSHA) only recognizes three types of diving: commercial, scientific, and recreational. It's astounding that so many professionals still errantly make a distinction between "technical" and "recreational" diving. They are the same. Argue all you wish… that's the law. Get used to it. ("Sport" and "recreational" are interchangeable terms that refer to the same category of diving.)

As one who has practiced deep diving professionally for over four decades, I am continually dismayed at the wealth of out-of-date or incorrect information offered about narcosis. Hopefully, with more expert participants writing on the subject based on actual diving experience, a more balanced view of the subject will be shared with

sport divers that will discourage them from taking unnecessary risks with improper educational resources. For those of us who actively practice deep diving in various applications, there is nothing so terrifying as the lack of proper training and materials for sport divers beyond the current existing "deep diver" programs within the mainstream certification agencies that are woefully inadequate.



Within the context of air diving, the effects of inert gas narcosis are second only to acute CNS oxygen toxicity in hazard to the scuba diver. Commonly known as "nitrogen narcosis", this condition was first described by Junod in 1835 when he discovered divers breathing compressed air: "the functions of the brain are activated, imagination is lively, thoughts have a peculiar charm and in some persons, symptoms of intoxication are present." Early caisson workers were occasional victims of befuddlement on otherwise simple tasks and some were reported to spontaneously burst into singing popular songs of that period. Much of the mysteries of compressed air impairment remained speculative until Benke zeroed in on elevated partial pressures of nitrogen as the culprit. His observations were reported in 1935 and depicted narcosis as "euphoric retardment of the higher mental processes and impaired neuromuscular coordination".

Other studies confirmed this phenomena and U.S. Navy divers reported narcosis a major factor in the salvage efforts on the sunken submarine ***Squalus*** in 1939. Working in depths of 240 fsw (72.7 m) in cold water, these divers reported loss of clear thought and reasoning. Several unusual entanglement scenarios resulted and in the normal work process at least one diver was reported to unexpectedly lose consciousness underwater on the wreck. Because of this, the Navy switched to then experimental Heliox mixtures marking the first major project with this gas. Bennett (1966) first related narcosis to the Greek word "nark", meaning numbness. The Greeks used this in association with the human reactive process to opium that produces drowsiness, stupefaction and a general feeling of well-being and lassitude.

At any rate, the best explanation appears to be the Meyer-Overton hypothesis relating the narcotic effect of an inert gas to its solubility in the lipid phase or fat. This is postulated to act as a depressant to the nervous system proportional to the gas amount going into solution. Mount (1979) has expressed the narcotic effect as determined by multiplying the solubility by the partition coefficient. By examining tables of various inert gases compared by solubility and partition coefficient it becomes abundantly clear that nitrogen is one of the least desirable gases in a breathing mixture for divers at depth. The "relative narcotic potency" is expressed as a number value with the highest number reflecting the least narcotic effect. Argon is extremely narcotic with a value of 0.43; Nitrogen is rated at 1.0 with Helium one of the least narcotic at 4.26.

Table: Relative Narcotic Potencies

Helium (He)	4.26	(least narcotic)
Neon (Ne)	3.58	
Hydrogen (H2)	1.83	
Nitrogen (N2)	1.00	
Argon (A)	0.43	
Krypton (Kr)	0.14	
Xenon (Xe)	0.039	(most narcotic)

As experienced divers more frequently dive to deeper depths in pursuit of wreck, cave exploration and photographic interests, the subject of inert gas narcosis becomes more ardently debated. Much practical discussion of narcosis "field" theory among scuba divers was originally taken on and conducted "underground" by a close-knit community of technical professional divers without a public forum of information exchange dating back to the 1970s. Narcosis was regarded as an occupational hazard that had to be dealt with in order to gain access to new cave systems, more remote wrecks, or the most spectacular drop-off walls.

Due to the controversial nature of deep diving within the traditional sport diving industry, an understandable reluctance to discuss actual diving practices was perpetuated. Little actual "field work" was published and a word of mouth grapevine developed to compare different diving techniques in widely diverse areas. In the late 1960s and early 1970s three distinctly different segments of emerging "technical" diving were conducting deep air dives. On the cave diving scene individuals such as Sheck Exley, Tom Mount, Frank Martz, Jim Lockwood, and Dr. George Benjamin pushed ever deeper with their explorations, while Bahamian and Caribbean groups led by Neil Watson and myself pushed beyond the 400 fsw (121.2 m) barrier for the first time in open water. Simultaneously, a whole new wreck diving cult with Peter Gimble, Al Giddings, Bob Hollis, Hank Keatts and Steve Bielenda was coming out of the shadows in the northeast to assault previously unreachable sites such as the ***Andrea Doria***.

Published accounts of narcosis experiences were largely limited to cave diving newsletters although I presented a quasi "how-to" paper on deep air methods in 1974 (*Extending the Working Capability and Depth of the Scuba Diver Breathing a Compressed Air Media)*. This presentation at The International Conference on Underwater Education in San Diego stimulated some limited exchange of information between the diverse communities but also focused criticism from national training agencies at the time. The "underground" once again retreated from the harsh glare of sport diver scrutiny and new breakthroughs and techniques reverted to word of mouth communications. As one veteran deep wreck explorer put it, "You can always tell a pioneer by the arrows in his back!"

In 1990 for the first time, the "technical diver" began to come out of the closet and stay a while, and in-depth discussions of narcosis went public.

Some of the earlier accounts by Cousteau (1947) relate instances of near total incapacitation at depths of only 150 fsw (45.5 m) and cite the supposed "Martini's Law" and the classic broad generalization of "Rapture of the Deep". In reality, the severity of impairment is drastically reduced in well equipped and experienced/adapted divers at greater depth. Narcosis is certainly a factor to be dealt with responsibly by divers, but many texts suggest levels of impairment that are far exaggerated for seasoned practitioners.

LIMITS AND OPINIONS

Today's diver has the advantage of extremely well engineered and high performance scuba gear that can markedly increase his performance. Design evolutions in buoyancy compensating devices (BCD's), scuba regulators, instrumentation, diving computers, less restrictive and more efficient thermal suits etc., all contribute to his ability to work deeper safely.

I would like to emphasize that deep air diving below 218 fsw (66 m) is generally not recommended given the alternatives available in today's industry. (This depth represents the outer limits of recommended oxygen exposures at 1.6 ATA of O2.) On high risk or particularly demanding dive scenarios this depth should be adjusted shallower. Many veteran air divers now opt for mixed gas to virtually eliminate narcosis and oxygen toxicity problems. What is the cut-off depth on air? This is clearly subjective and must be answered by the individual diver who considers his own narcosis susceptibility, his objective and his access and financial commitment to mixed gas equipment.

Wes Skiles (deceased in 2010), a highly experienced and respected cave diver, expressed his preference for mixed gas on any penetrations below 130 fsw (39.4 m) primarily because of his admitted low tolerance for narcosis. This was back in 1990. Members of the scientific diving community still practice air dives to 190 fsw (57.6 m) officially (with far deeper dives reported "unofficially"). Mount and I have long suggested practical air limits of between 250 and 275 fsw (75.7 and 83.3 m) for properly trained and adapted professionals… but it is necessary to understand that such depths exceed the typical "working depth" guidelines for oxygen and place the diver in the O2 exceptional exposure zone. (The reader is directed to references specifically on oxygen toxicity to better understand various O2 exposure theories and phenomena.) Mixed gas solves some problems for some people, but it adds several new problems and operational considerations to the equation: expense, heat loss, extended deco times, etc. For many experienced air practitioners, deep air diving remains a viable choice simply because, done with the proper disciplines and training, it is a reasonable exercise. That is to say it can be approached with an acceptable level of risk. But new divers venturing beyond traditional sport limits must be fully cognizant of the elements of risk and that deep diving will reduce the margin for error and the attendant increased chance for injury or death must be understood. Diving within one's limitations should be etched firmly in the deep diver's memory. Depths below 130 fsw (39.4 m) can be safely explored but such diving cannot be taken lightly.

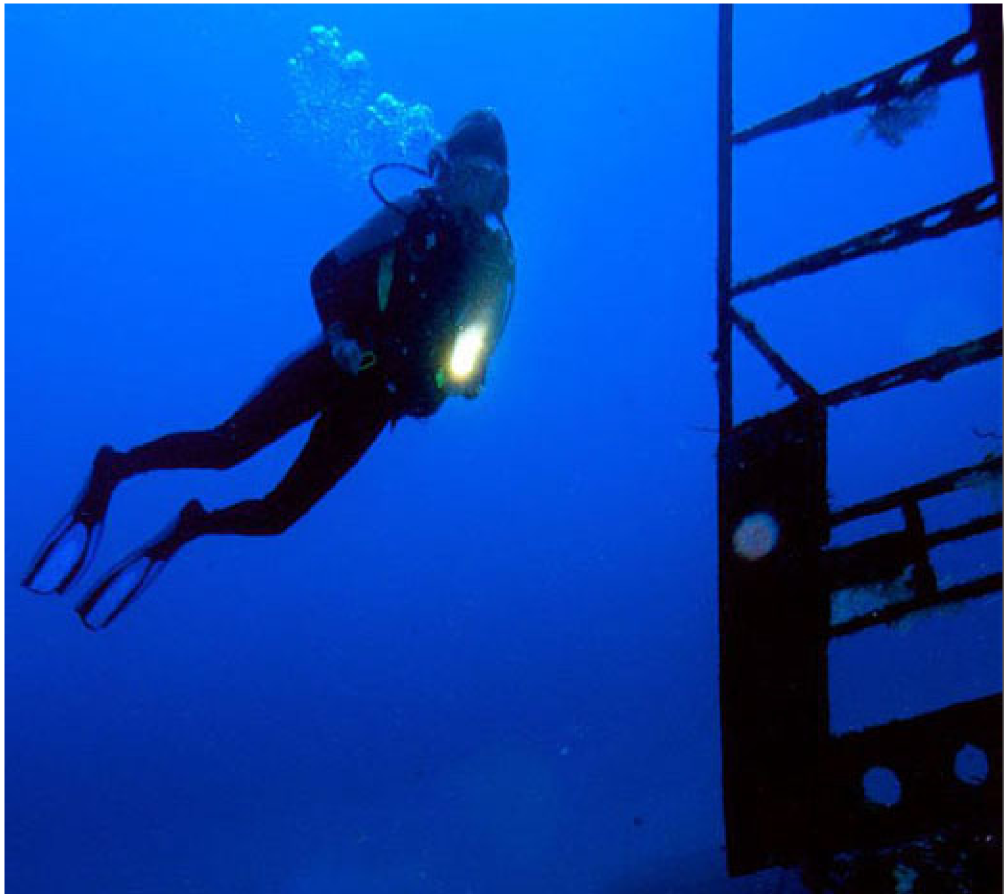
PREDISPOSING FACTORS

Factors contributing to narcosis onset and severity include:

- Increased partial pressures of CO2 (hard work, heavy swimming etc.)
- Cold
- Alcohol use or "hangover" conditions
- Fatigue
- Work of breathing, e.g. inherent resistance within the breathing system on inhalation/exhalation cycles
- Anxiety or apprehension, FEAR
- Effects of motion sickness medications
- Rate of descent (speed of decompression)
- Vertigo or spatial disorientation caused by no "up" reference such as in bottomless clear "blue water" or in severely restricted visibility
- Task loading stress
- Time pressure stress
- Another lesser-known contributory factor is increased oxygen partial pressure

ADAPTATION

Narcosis can be controlled to varying degrees specific to individuals but tolerances can change from day to day. Almost any experienced deep diver will tell you that "adaptation" to narcosis takes place. Bennett (1990) notes, "the novice diver may expect to be relatively seriously affected by nitrogen narcosis, but subjectively at least there will be improvement with experience. Frequency of exposure does seem to result in some level of adaptation." The actual mechanics of adaptation are not clearly understood or proven but most deep divers agree that they will perform better with repeated progressively deeper penetrations on a cumulative basis.



During a series of experimental dives in 1990, I had no significant impairment at 452 fsw (137 m) for my brief exposure, approximately 4.5 minutes in the critical zone (especially for O2 toxicity) below 300 fsw (91 m). I was able to successfully complete a series of higher math and thought/reasoning problems while suspended at the deepest level. But this is probably the extreme end of adaptation; I dove every week for over a year with never more than a six-day lay-off. My 627 dives during this period included 103 below 300 fsw (91 m).

For the diver who regularly faces deep exposures, a tolerance far in excess of the un-adapted diver will be exhibited. A gradual work-up to increasing depths is the best recommendation. I refer to making each first dive of the day progressively deeper than the day before to build tolerances, i.e. Day 1: first dive to 150 fsw (45.5 m), Day 2: first dive to 175 fsw (53.2 m) etc. Subsequent dives on Day 1 and Day 2 would be shallower than the first. This process should be over several days' time if the diver has been away from deep diving for more than two weeks. Adaptation appears to be lost exponentially as acquired so no immediate increased narcosis susceptibility will necessarily be evident but divers are cautioned to exercise great conservatism if any lay-off is necessitated.

THE DIVING REFLEX

Back in the mid-1800s Paul Bert observed pronounced brachycardia (lowered heartbeat) in ducks while diving. Suk Ki Hong (1990) describes "a reflex phenomenon that is accompanied by an intense peripheral vasoconstriction, a drastic reduction in the cardiac output, and a significant reduction of O2 consumption". Hickey and Lundgren (1984) further noted aspects of the mammalian diving reflex to include "muscular relaxation, astonishing levels of brachycardia, e.g., heart rates 13% of pre-dive levels in harbor seals... and depressed metabolism. All of these adaptations conserve the body's energy stores." Simply put, this reflex serves to apparently slow down most vital, internal functions such as heartbeat and shunt blood from the extremities enabling the diving seal or dolphin to more effectively utilize its single breath oxygen load while underwater.

Similar responses have been noted in human subjects. Several divers stumbled onto this in the late 1960s and began to effectively incorporate facial immersion breathing periods prior to diving. Exley and Watson practiced such techniques and I became a leading proponent of surface and ten-foot depth (3.03 m) level extended breathing with my diving mask and hood removed before dives below 300 fsw (91 m) in 1971. I have recorded dramatic reductions in my heart rate and respiration rate by following a protocol of ten minutes facial immersion breathing at the surface, then five minutes at ten to fifteen fsw (3.03 to 4.5 m) from a pony bottle. My pulse has been measured at twelve to fifteen beats per minute and respiration rate dropped to two a minute at deep depths (dive to 405 fsw/122.7 m in 1977). Other divers have adopted varying uses of the diving reflex technique in conjunction with meditation disciplines with significant success. Of the divers using this technique, many report pronounced reduction of narcosis, reduced air consumption and better coordination at depth. Regardless of the scientific proof challenges, the technique is becoming more widespread and its subjective benefits certainly bear closer scrutiny.

EQUIPMENT

At depth the air we breathe has far greater density and can be an operational problem if the scuba regulator is not carefully selected to comfortably deliver adequate volumes upon demand. Breathing resistance can markedly increase onset and progression of narcosis. Until the 1990s many so-called "professional" regulator models fell sadly short on performance below 200 fsw (60.6 m).

Exhalation resistance is a prime factor in breathing control, perhaps more so than inhalation ease. Studies have shown exhalation detriments to be the most significant fatigue element in underwater breathing tests. So how do you choose between the dozens of models offered? Some benchmark can be derived from perusal of U.S. Navy test reports but sometimes results can offer inconclusive appraisals. Back in the late 1980s, the Tekna 2100 series unit basically failed the Navy tests for high performance due its unique second stage design, but was popular regulator with many experienced deep divers since its introduction. I used it on my record setting 452 fsw (137 m) dive in Roatan and had complete satisfaction. But remember that the numbers of regulators that are genuinely suited for deep diving are contained on a very short list. (I personally use the superlative Titanium series from Atomic since 1996.)

Michele and Howard Hall using rebreathers to film IMAX 3D documentary at 220 feet (67 meters), 2003 (Hall archives)

Now is a good time to insure that you select comparable quality instruments compatible with the depths you anticipate exploring. Keep in mind that many depth gauges and dive computers have depth limitations that will render them useless much over normal sport diving ranges. Make certain that the information is displayed in an easily understood format. If you have a hard time deciphering what you are looking at on the surface, imagine the problem at 250 fsw (75.7 m) under the influence of narcosis.

ON THE DIVE

Wreck and drop-off wall divers should use descents undertaken with a negative glide to the desired operational depth then the BCD is used to quickly attain neutral buoyancy. Do not waste energy and generate CO2 using leg kicking to maintain position in the water column. Slow, deep ventilations with minimal exertions will keep CO2 down and reduces onset and severity of narcosis. Narcosis has been reported subjectively to be most strong when first arriving at depth. Allow yourself a stop-activity period to monitor your instruments and let the initial narcosis effects stabilize.

Diving deep properly is more a mental exercise than a physical one. The diver must constantly be aware of his own limitations to narcosis and not hesitate to abort a dive if impairment becomes unreasonable. If narcosis is severe on descent, slow the rate or stop completely until symptoms are controlled. If possible face an "up" reference at all times such as anchor line or face the drop-off to orient the wall perpendicularly to the surface. This affords more accurate references if you are sinking or rising. If necessary, hold on to the descent line or a drop-off wall outcropping to insure of control of depth while narcosis can be evaluated.

SYMPTOMS

In spite of the warnings of various academicians, it is unlikely that the diver will experience "rapture" or the uncontrollable desire to kiss a fish or dance with an imaginary mermaid. However, there is a wide range of individual susceptibility. Almost all divers will be impaired eventually. This will manifest in many ways.

Most divers are acquainted with traditional depictions of narcosis symptomatology (lightheadedness, slowed reflexes, euphoria, poor judgment, even numbness etc.). But many early symptoms are more classically subtle. Initially divers will notice, in many cases, a reduced ability to read fine graduations in a depth gauge diving computer, or watch along with increased awareness of sensitivity to sound such as exhalation and inhalation noise. Perceptual narrowing may limit some divers to successful execution of only limited task loading.

Short-term memory loss and perceptions of time can be affected. With experience, divers can learn to control these deficits to some extent. **But these very real dangers cannot be underestimated.** A diver unaware of his depth, bottom time or remaining air volume is about to become a statistic!

NARCOSIS SYMPTOMS

- Lightheadedness
- Euphoria
- Drunkenness
- Impaired neuromuscular coordination
- Hearing sensitivity or hallucination
- Slowed mental activity
- Decreased problem solving capacity
- Overconfidence
- Short-term memory loss or distortions
- Improper time perceptions
- Fine work deterioration
- Exaggerated movements
- Numbness and tingling in lips, face and feet
- Stupor
- Sense of impending blackout
- Levity or tendency to laughter
- Depressive state
- Visual hallucination or disturbances
- Perceptual narrowing
- Less tolerance to stress
- Exaggerated (oversized) handwriting
- Amnesia
- Loss of consciousness
- Retardation of higher mental processes
- Retardation of task performances
- Slurred speech
- Poor judgment
- Slowed reaction time and reflex ability
- Loss of mechanical dexterity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UNDERWATER AWARENESS

Buddy teams need to be more aware of each other in deep dives. Just as frequent scanning of instruments is mandated so is confirmation of your buddy's status. Generally, you should look for him about every three breaths and observe him for any overt signs of impairment. Quick containment of a problem situation in its development is vital to prevent a stressful rescue event that may be difficult to perform at depth.

In 1972 I offered an effective underwater narcosis check between divers. We were frequently diving very deep with long working bottom times on this contract in the Virgin Islands. I had a secret dread of one of our team's divers being overcome without our immediate knowledge. So I came up with a childishly simple hand signal response exercise for use at depth to detect narcosis. If one diver flashed a one-finger signal to another diver, it was expected that the diver would answer with a two-finger signal.

A two-fingered signal was answered with three-fingers; if you really wanted to screw a guy up you gave him all five fingers and then he had to use two hands to come up with a six-finger response. We reasoned that if a diver was not able to respond quickly and correctly to the signal given, then sufficient impairment was presumed to abort his dive. It worked great for us then and I still use it today. Over the years, scores of divers have reported using the "Gilliam narcosis signals" (also known as "The Finger") with success.


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Although narcosis effects are generally eliminated by ascent, it is important to understand that many divers will experience some degree of amnesia of their performance at depth. Commercial divers have reported successful completion of a work project to the diving supervisor upon ascent, only to learn later that the objective was not completed at all! Less experienced deep divers will typically not remember their greatest depth or bottom time unless disciplined to record it on a slate prior to ascent. Again, the experienced deep diver will sharply focus on his job objectives and constantly monitor his instruments. Modern devices such as dive computers greatly improve safety controls with maximum depth and time memories as well as decompression planning models.

THE MOUNT-MILNER TEST

In 1965 a research project was conducted by professional diver Tom Mount and psychiatrist Dr. Gilbert Milner to determine the effects of anticipated behavior modeling in diving students with respect to narcosis. Three control groups of four students with equal male/female ratios were trained in identical dive classes except:

Group One was taught that a diver will get narcosis at 130 fsw (39.4 m), and much emphasis was placed on the high probability of narcosis impairment with severe symptoms.

Group Two was taught of the existence of narcosis, the symptoms and depths of occurrence cited as beginning at 100 fsw (30.3 m), but were not as intimidated with narcosis manifestations.

Group Three was well educated on narcosis with three full hours of lecture on symptoms, risk, danger and known research. They were told that divers with strong will power as postulated by Miles (1961) could mentally prepare themselves and greatly reduce the effects.

Prior to the open water deep dives all students were given two dives to 30 fsw (9.1 m) and two dives to 100 fsw (30.3 m) to develop good breathing techniques.

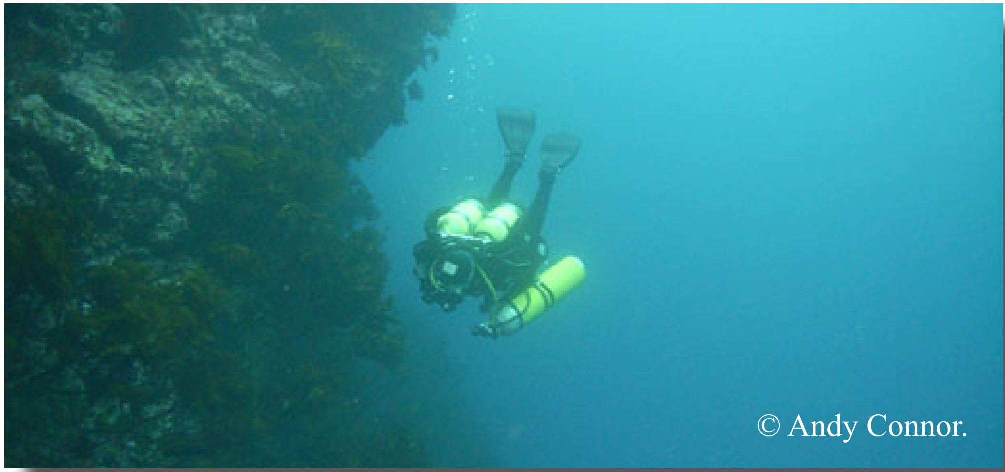
Before the actual dives for testing purposes, the students were taken on a 50 fsw (15.2 m) dive where the tests were performed so a mental/dexterity familiarity could be achieved with the format of the test problems. Changes were then made in the test so they could not be performed from memory. The tests consisted of handwriting evaluations, pegboard testing, math, and ball bearing placement in a long-necked narrow bottle etc.

In the initial test depth of 130 fsw (39.4 m), divers in Group One had minor-to-above-average narcosis problems while Group Two and three divers had little effect on test scores.

At the 180 fsw (54.6 m) test depth, two Group One divers dropped from the exercise due to severe narcosis problems and were removed from the dive. All Group Two divers were affected although still functioning at about 50% test levels. Group Three divers had minor impairment.

At the 200 fsw (60.6 m) test depth, all divers in Group One and two from Group Two were dropped due to severe narcosis and apprehension. Group Three divers actually showed slight improvement in test scores.

At the 240 fsw (72.7 m) test depth, one diver was dropped from Group Two and one from Group Three due to severe narcosis. The remaining Group Two diver and three Group Three divers showed levels of impairment but again scores and performance showed improvement over the previous depth level. One diver, a female from Group Three, registered her **highest** scores on all tests at the 240 fsw (72.7 m) level.



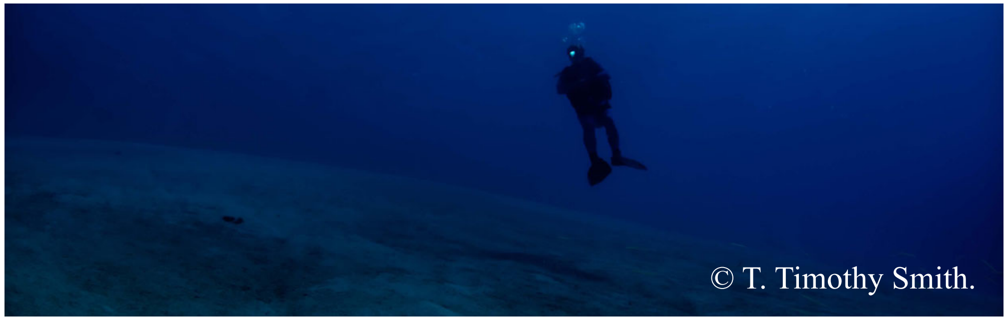
Concurrent testing of experienced deep divers showed seven out of ten divers with no decrease in performance or scores at the 200 fsw (60.6 m) test level. The three divers with decreased performance finished the testing (two with perfect scores) but required additional time than was usual. At 240 fsw (72.7 m), five out of ten performed all tests with no decreased performance. One diver had problems with the ball bearing test but perfect scores on the pegboard, math and handwriting. The other two showed up to 42% deficits and had problems completing the tests.

The obvious conclusions include a subjective validation to both "adaptation" and the negative influence of "modeling" behavior in those groups of divers pre-conditioned that narcosis was inevitable and severe. The Group Three divers with little prior diving experience were satisfactorily still performing at the 200 fsw (60.6 m) level and three divers continued to perform (with one showing improvement still) at the 240 fsw (72.7 m) test level.

If we teach our children that all dogs will bite, we can safely assume that when presented with a specimen even as lowly as a toy poodle (which should probably be shot on sight anyway), we can expect a high fear index. Likewise, if we teach our dive students that narcosis is a finite, unyielding biophysical wall, then we can logically expect such conditioning to impair their performance beyond a more realistically educated diver lacking pre-conceived phobias and suggestions. Education is the key to performance and safety.

CONCLUSION

Depth limitation largely becomes a decision then based upon narcosis levels and gas supply (until the O2 toxicity range is entered). Most divers will be able to function well in excess of the so-called 130 fsw (39.4 m) limit with even a little practice.



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Interestingly, the first edition of the NOAA Diving Manual published in the mid-1970s contained this notation on narcosis: "Experience, frequent exposure to deep diving, and a high degree of training may permit divers to dive on air as deep as 200 fsw (60.6 m) . . ." Although scientific diving programs and university based research groups generally advocated air diving to around this recommended limit, a significant proportion of dives were conducted in far deeper depths if necessary for observation or collection purposes including dives beyond 300 fsw (91 m). The proliferation of "Do as I say, not as I do" mentalities still dominate all factions of the industry primarily for fear of critical condemnation by less realistic "experts".

All divers should exercise prudence and reasonable caution in all aspects of deep diving but particularly so when it comes to narcosis. Experience is vital before attempting progressively deeper dives. Ideally, the diver should be seeking out the benefit of training by a competent, well-experienced deep diving instructor before a penetration below "entry level/open water" training diving depths. Don't try to obtain field experience on your own or with another buddy. The historical record provides too many fatalities or near misses due to narcosis to warrant such a risk.

Many critics condemned even the discussion of practical operational narcosis planning and dismissed those of us who advocated more realistic guidelines as members of the "lunatic fringe". Happily, most of that misguided ultra-conservatism has been withdrawn. I contend that by professionally addressing the questions of the real risks and real experiences associated with narcosis and deep diving, we will more responsibly serve today's diver who, in many cases, is already undertaking dives beyond his ability, training and operational physiology because no proper advanced deep diver training is offered through the traditional national training agencies. Truth in education is critical to any learning process and especially with diving. Let's not shy away from our responsibilities as diving educators by holding fast to the naive belief that all sport diving stops at 130 fsw (39.4 m). For many divers 130 fsw (39.4 m) is a reasonable limit… but others will go deeper. They will be safer and more likely to observe a practical limit if we provide the training to better identify the real hazards and the required commitments to plan deeper diving.

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